

	Docum ent ID	U	Title	Current OR
1	US 20040 02159 1 A1	<input type="checkbox"/>	Processor, encoder, decoder, and electronic apparatus	341/60
2	US 20040 00574 4 A1	<input checked="" type="checkbox"/>	Crystallization apparatus, optical member for use in crystallization apparatus, crystallization method, thin film transistor, and display	438/166
3	US 20030 22307 5 A1	<input checked="" type="checkbox"/>	Compact interference measuring apparatus detecting plurality of phase difference signals	356/491
4	US 20030 17920 9 A1	<input checked="" type="checkbox"/>	Dynamic computation of chipset-supported accelerated graphics port aperture sizes	345/543
5	US 20030 15100 2 A1	<input checked="" type="checkbox"/>	Apparatus for inspecting mask	250/492 .1
6	US 20030 04292 0 A1	<input checked="" type="checkbox"/>	Exposure apparatus, control method for the same, and device fabricating method	324/752
7	US 20030 01174 7 A1	<input checked="" type="checkbox"/>	Digital, high-resolution motion-picture camera	352/166
8	US 20030 00273 9 A1	<input checked="" type="checkbox"/>	Method and apparatus for using rotatable templates within look-up tables to enhance image reproduction	382/216
9	US 20030 00256 6 A1	<input checked="" type="checkbox"/>	System and method for shifting the phase of pseudorandom noise code in direct sequence spread spectrum communications	375/147
10	US 20020 18448 0 A1	<input checked="" type="checkbox"/>	Vectorized table lookup	712/300
11	US 20020 18170 8 A1	<input checked="" type="checkbox"/>	Apparatus and method for generating scrambling code in mobile communication system	380/252
12	US 20020 16980 8 A1	<input checked="" type="checkbox"/>	System and method for reordering data	708/204
13	US 20020 12626 8 A1	<input checked="" type="checkbox"/>	Projection exposure method, projection exposure apparatus, and methods of manufacturing and optically cleaning the exposure apparatus	355/67
14	US 20020 09055 7 A1	<input checked="" type="checkbox"/>	MASK AND METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE	430/5
15	US 20020 05727 6 A1	<input checked="" type="checkbox"/>	Data processing apparatus, processor and control method	345/555
16	US 20020 01369 0 A1	<input checked="" type="checkbox"/>	PACKET CLASSIFICATION STATE MACHINE HAVING REDUCED MEMORY STORAGE REQUIREMENTS	703/22
17	US 20020 01087 8 A1	<input checked="" type="checkbox"/>	Circuit configuration for generating control signals for testing high-frequency synchronous digital circuits	714/25

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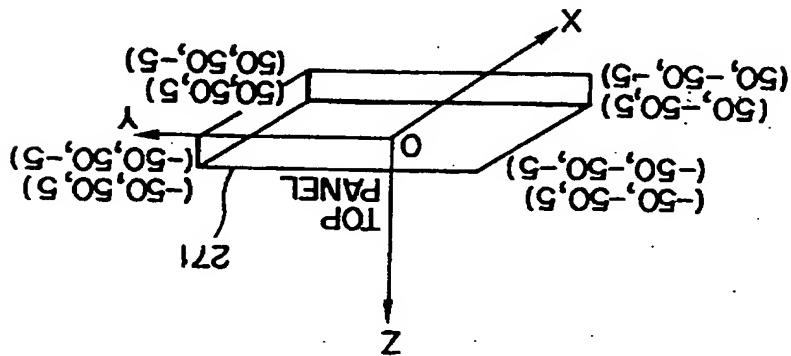


FIG. 82

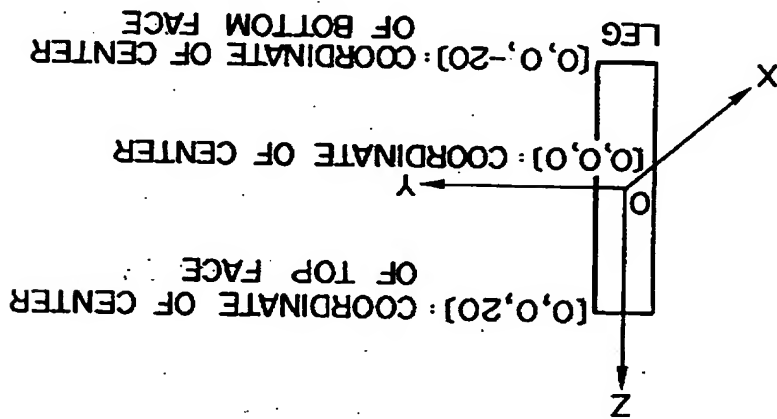


FIG. 83

WORLD TRANSFORMATION				WORLD TRANSFORMATION			
100	0	0	1	100	0	0	1
0	0	0	0	45	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
MATRIX OF TOP PANEL				MATRIX OF LEG 272			
145	0	0	1	55	20	1	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

FIG. 84

	Docum ent ID	U	Title	Current OR
18	US 20020 00267 1 A1	<input checked="" type="checkbox"/>	Parallel processing of multiple data values within a data word	712/300
19	US 20010 02147 7 A1	<input checked="" type="checkbox"/>	Method of manufacturing a device by means of a mask phase-shifting mask for use in said method	430/5
20	US 67252 98 B1	<input checked="" type="checkbox"/>	Method and system for filter-processing by ensuring a memory space for a ring-buffer in digital signal processor	710/56
21	US 67184 92 B1	<input checked="" type="checkbox"/>	System and method for arranging bits of a data word in accordance with a mask	714/701
22	US 67150 66 B1	<input checked="" type="checkbox"/>	System and method for arranging bits of a data word in accordance with a mask	712/300
23	US 66877 71 B2	<input checked="" type="checkbox"/>	Parallel processing of multiple data values within a data word	710/62
24	US 66865 91 B2	<input checked="" type="checkbox"/>	Apparatus for inspecting mask	250/311
25	US 66836 15 B1	<input checked="" type="checkbox"/>	Doubly-virtualized texture memory	345/543
26	US 66779 52 B1	<input checked="" type="checkbox"/>	Texture download DMA controller synching multiple independently-running rasterizers	345/505
27	US 66571 81 B1	<input checked="" type="checkbox"/>	Optical element used in compact interference measuring apparatus detecting plurality of phase difference signals	250/216
28	US 66503 33 B1	<input checked="" type="checkbox"/>	Multi-pool texture memory management	345/552
29	US 66503 17 B1	<input checked="" type="checkbox"/>	Variable function programmed calculator	345/168
30	US 66292 39 B1	<input checked="" type="checkbox"/>	System and method for unpacking and merging bits of a data word in accordance with bits of a mask word	712/300
31	US 66291 15 B1	<input checked="" type="checkbox"/>	Method and apparatus for manipulating vectored data	708/209
32	US 66188 04 B1	<input checked="" type="checkbox"/>	System and method for rearranging bits of a data word in accordance with a mask using sorting	712/300
33	US 65871 13 B1	<input checked="" type="checkbox"/>	Texture caching with change of update rules at line end	345/557
34	US 65446 94 B2	<input checked="" type="checkbox"/>	Method of manufacturing a device by means of a mask phase-shifting mask for use in said method	430/5
35	US 65387 22 B2	<input checked="" type="checkbox"/>	Projection exposure method, projection exposure apparatus, and methods of manufacturing and optically cleaning the exposure apparatus	355/53
36	US 65265 11 B1	<input checked="" type="checkbox"/>	Apparatus and method for modifying microprocessor system at random and maintaining equivalent functionality in spite of modification, and the same microprocessor system	713/190
37	US 64461 98 B1	<input checked="" type="checkbox"/>	Vectorized table lookup	712/300
38	US 64406 14 B1	<input checked="" type="checkbox"/>	Mask and method of manufacturing semiconductor device	430/5
39	US 64382 73 B1	<input checked="" type="checkbox"/>	Method and apparatus for using rotatable templates within look-up tables to enhance image reproduction	382/296

TRANSFORMATION MATRIX OF
PARALLEL DISPLACEMENT
OF $[T_x, T_y, T_z]$

$$M_P = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{bmatrix}$$

TRANSFORMATION MATRIX OF
SCALE CONVERSION OF
 $[S_x, S_y, S_z]$

$$M_S = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TRANSFORMATION MATRIX OF
ROTATION BY θ AROUND X
AXIS

$$M_{Rx} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos \theta & \sin \theta & 0 \\ 0 & -\sin \theta & \cos \theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TRANSFORMATION MATRIX OF
ROTATION BY θ AROUND Y AXIS

$$M_{Ry} = \begin{bmatrix} \cos \theta & 0 & -\sin \theta & 0 \\ 0 & 1 & 0 & 0 \\ \sin \theta & 0 & \cos \theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TRANSFORMATION MATRIX
OF ROTATION BY θ AROUND
Z AXIS

$$M_{Rz} = \begin{bmatrix} \cos \theta & \sin \theta & 0 & 0 \\ -\sin \theta & \cos \theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

FIG. 85

	Docum ent ID	U	Title	Current OR
40	US 64376 67 B1	<input checked="" type="checkbox"/>	Method of tuning thin film resonator filters by removing or adding piezoelectric material	333/188
41	US 64249 34 B2	<input checked="" type="checkbox"/>	Packet classification state machine having reduced memory storage requirements	703/25
42	US 64113 68 B1	<input checked="" type="checkbox"/>	Projection exposure method, projection exposure apparatus, and methods of manufacturing and optically cleaning the exposure apparatus	355/67
43	US 64082 75 B1	<input checked="" type="checkbox"/>	Method of compressing and decompressing audio data using masking and shifting of audio sample bits	704/500
44	US 63969 44 B1	<input checked="" type="checkbox"/>	Inspection method for Levenson PSM mask	382/144
45	US 63361 13 B1	<input checked="" type="checkbox"/>	Data management method and data management apparatus	707/6
46	US 62632 99 B1	<input checked="" type="checkbox"/>	Geometric aerial image simulation	703/5
47	US H0019 70 H	<input checked="" type="checkbox"/>	Variable function programmed system	712/32
48	US 61974 56 B1	<input checked="" type="checkbox"/>	Mask having an arbitrary complex transmission function	430/5
49	US 61733 93 B1	<input checked="" type="checkbox"/>	System for writing select non-contiguous bytes of data with single instruction having operand identifying byte mask corresponding to respective blocks of packed data	712/224
50	US 61717 31 B1	<input checked="" type="checkbox"/>	Hybrid aerial image simulation	430/5
51	US 61656 92 A	<input checked="" type="checkbox"/>	Method for manufacturing a semiconductor device and an exposure mask used therefor	430/311
52	US 61449 86 A	<input checked="" type="checkbox"/>	System for sorting in a multiprocessor environment	709/201
53	US 61191 98 A	<input checked="" type="checkbox"/>	Recursive address centrifuge for distributed memory massively parallel processing systems	711/5
54	US RE367 52 E	<input checked="" type="checkbox"/>	Cryptographic authentication of transmitted messages using pseudorandom numbers	380/262
55	US 60814 40 A	<input checked="" type="checkbox"/>	Ternary content addressable memory (CAM) having fast insertion and deletion of data values	365/49
56	US 60527 69 A	<input checked="" type="checkbox"/>	Method and apparatus for moving select non-contiguous bytes of packed data in a single instruction	712/3
57	US 60363 50 A	<input checked="" type="checkbox"/>	Method of sorting signed numbers and solving absolute differences using packed instructions	708/201
58	US 60159 76 A	<input checked="" type="checkbox"/>	Fabrication apparatus employing energy beam	250/492 .23
59	US 60115 66 A	<input checked="" type="checkbox"/>	System and method to display raster images with negligible delay time and reduced memory requirements	345/600
60	US 60092 03 A	<input checked="" type="checkbox"/>	Method and apparatus for hybrid VLC bitstream decoding	382/233
61	US 60055 03 A	<input checked="" type="checkbox"/>	Method for encoding and decoding a list of variable size integers to reduce branch mispredicts	341/67
62	US 59371 83 A	<input checked="" type="checkbox"/>	Enhanced binary decision diagram-based functional simulation	703/14

RELATIVE TRANSFORMATION MATRIX OF LEG 272	RELATIVE TRANSFORMATION MATRIX OF LEG 273	RELATIVE TRANSFORMATION MATRIX OF LEG 274	RELATIVE TRANSFORMATION MATRIX OF LEG 275
$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 45 & -45 & -25 & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 45 & 45 & -25 & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -45 & -45 & -25 & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -45 & 45 & -25 & 1 \end{bmatrix}$

FIG. 86

	Docum ent ID	U	Title	Current OR
63	US 59369 78 A	<input checked="" type="checkbox"/>	Shortened fire code error-trapping decoding method and apparatus	714/762
64	US 59209 00 A	<input checked="" type="checkbox"/>	Hash-based translation method and apparatus with multiple level collision resolution	711/216
65	US RE361 81 E	<input checked="" type="checkbox"/>	Pseudorandom number generation and cryptographic authentication	713/168
66	US 58929 60 A	<input checked="" type="checkbox"/>	Method and computer system for processing a set of data elements on a sequential processor	712/7
67	US 58700 85 A	<input checked="" type="checkbox"/>	Generating text strings	345/551
68	US 58689 52 A	<input checked="" type="checkbox"/>	Fabrication method with energy beam	216/66
69	US 58677 24 A	<input checked="" type="checkbox"/>	Integrated routing and shifting circuit and method of operation	712/22
70	US 58599 12 A	<input checked="" type="checkbox"/>	Digital information privacy system	380/42
71	US 58416 83 A	<input checked="" type="checkbox"/>	Least significant bit and guard bit extractor	708/497
72	US 58411 45 A	<input checked="" type="checkbox"/>	Method of and system for exposing pattern on object by charged particle beam	250/492 .22
73	US 57844 94 A	<input checked="" type="checkbox"/>	Method and apparatus for prestoring dequantization information for DCT VLC decoding	382/233
74	US 57844 27 A	<input checked="" type="checkbox"/>	Feedback and shift unit	377/72
75	US 57833 36 A	<input checked="" type="checkbox"/>	Mask for exposure	430/5
76	US 57651 81 A	<input checked="" type="checkbox"/>	System and method of addressing distributed memory within a massively parallel processing system	711/5
77	US 57520 00 A	<input checked="" type="checkbox"/>	System and method for simulating discrete functions using ordered decision arrays	703/14
78	US 56969 22 A	<input checked="" type="checkbox"/>	Recursive address centrifuge for distributed memory massively parallel processing systems	711/5
79	US 56965 33 A	<input checked="" type="checkbox"/>	Method for selecting an item on a graphics screen	345/823
80	US 56447 09 A	<input checked="" type="checkbox"/>	Method for detecting computer memory access errors	714/53
81	US 56279 66 A	<input checked="" type="checkbox"/>	Method for simulating the parallel processing of video data	714/49
82	US 56276 39 A	<input checked="" type="checkbox"/>	Coded aperture imaging spectrometer	356/310
83	US 56130 01 A	<input checked="" type="checkbox"/>	Digital signature verification technology for smart credit card and internet applications	380/254
84	US 55839 85 A	<input checked="" type="checkbox"/>	Graphic display processing apparatus for improving speed and efficiency of a window system	345/534
85	US 55772 00 A	<input checked="" type="checkbox"/>	Method and apparatus for loading and storing misaligned data on an out-of-order execution computer system	714/50

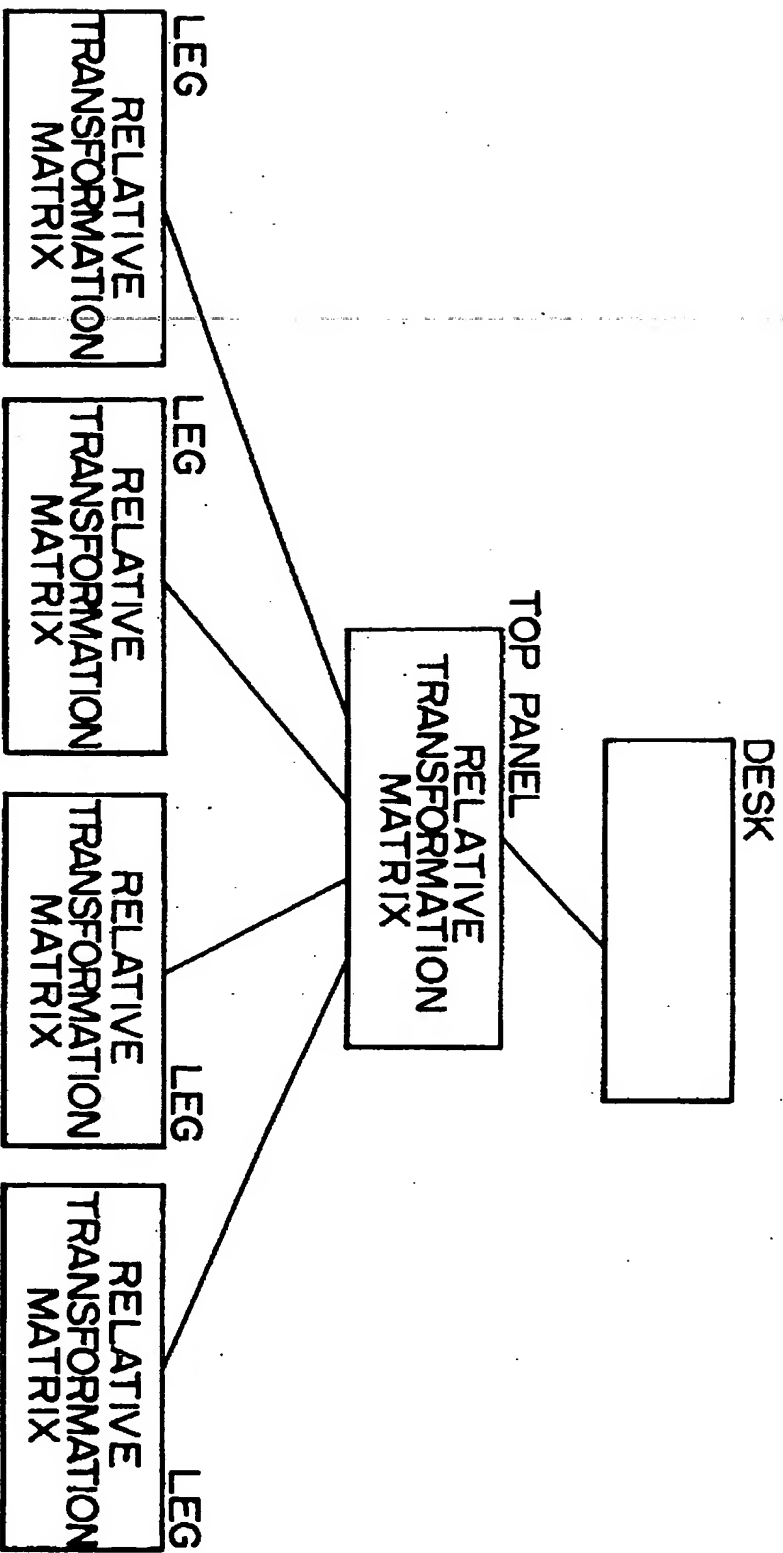


FIG. 87

	Document ID	U	Title	Current OR
86	US 5559722 A	<input checked="" type="checkbox"/>	Process, apparatus and system for transforming signals using pseudo-SIMD processing	341/50
87	US 5555003 A	<input checked="" type="checkbox"/>	Method for selecting an item on a graphics screen	345/856
88	US 5553197 A	<input checked="" type="checkbox"/>	Devices for use in neural processing	706/41
89	US 5546225 A	<input checked="" type="checkbox"/>	High resolution printing technique by using improved mask pattern and improved illumination system	359/559
90	US 5539663 A	<input checked="" type="checkbox"/>	Process, apparatus and system for encoding and decoding video signals using temporal filtering	348/406.1
91	US 5539662 A	<input checked="" type="checkbox"/>	Process, apparatus and system for transforming signals using strength-reduced transforms	358/1.15
92	US 5537338 A	<input checked="" type="checkbox"/>	Process and apparatus for bitwise tracking in a byte-based computer system	709/204
93	US 5535138 A	<input checked="" type="checkbox"/>	Encoding and decoding video signals using dynamically generated quantization matrices	709/204
94	US 5532940 A	<input checked="" type="checkbox"/>	Process, apparatus and system for selecting quantization levels for encoding video signals	709/204
95	US 5528238 A	<input checked="" type="checkbox"/>	Process, apparatus and system for decoding variable-length encoded signals	341/67
96	US 5502832 A	<input checked="" type="checkbox"/>	Associative memory architecture	711/108
97	US 5497436 A	<input checked="" type="checkbox"/>	System and method for bit-masked color signal scaling	382/298
98	US 5497340 A	<input checked="" type="checkbox"/>	Apparatus and method for detecting an overflow when shifting N bits of data	708/552
99	US 5493514 A	<input checked="" type="checkbox"/>	Process, apparatus, and system for encoding and decoding video signals	709/247
100	US 5493513 A	<input checked="" type="checkbox"/>	Process, apparatus and system for encoding video signals using motion estimation	709/247
101	US 5475766 A	<input checked="" type="checkbox"/>	Pattern inspection apparatus with corner rounding of reference pattern data	382/144
102	US 5430862 A	<input checked="" type="checkbox"/>	Emulation of CISC instructions by RISC instructions using two pipelined stages for overlapped CISC decoding and RISC execution	703/26
103	US 5423010 A	<input checked="" type="checkbox"/>	Structure and method for packing and unpacking a stream of N-bit data to and from a stream of N-bit data words	341/60
104	US 5418799 A	<input checked="" type="checkbox"/>	Semiconductor laser element structure	372/44
105	US 5405490 A	<input checked="" type="checkbox"/>	Flat display device and method for manufacturing the same	216/14
106	US 5398319 A	<input checked="" type="checkbox"/>	Microprocessor having apparatus for dynamically controlling a kind of operation to be performed by instructions to be executed	712/226
107	US 5381425 A	<input checked="" type="checkbox"/>	System for encoding and decoding of convolutionally encoded data	714/793
108	US 5377270 A	<input checked="" type="checkbox"/>	Cryptographic authentication of transmitted messages using pseudorandom numbers	380/262

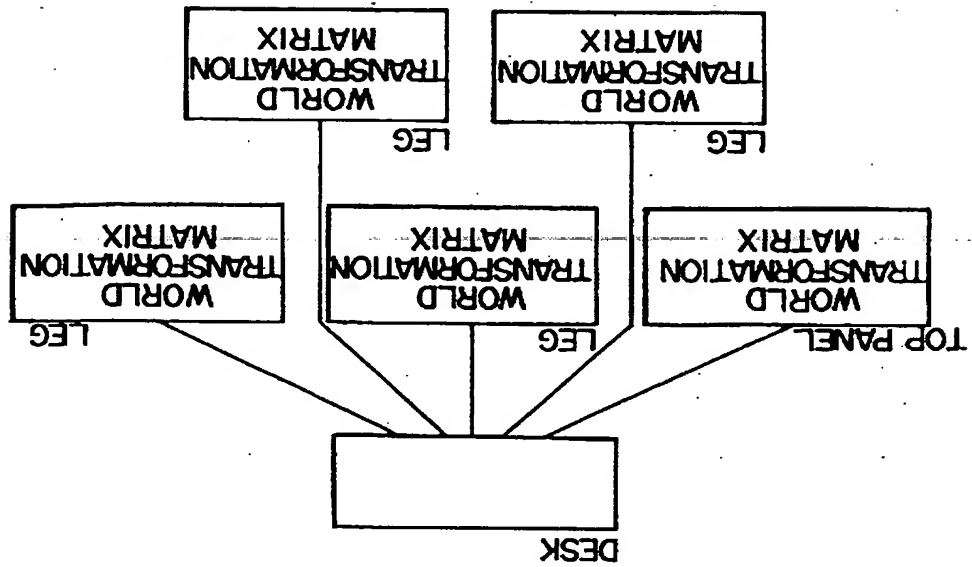


FIG. 89

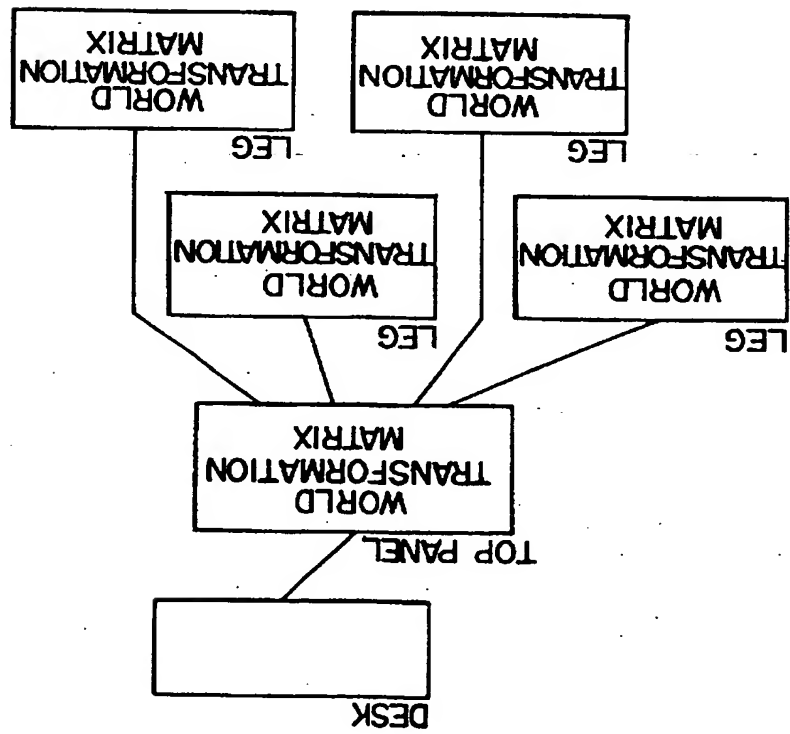


FIG. 88

	Docum ent ID	U	Title	Current OR
109	US 53634 48 A	<input checked="" type="checkbox"/>	Pseudorandom number generation and cryptographic authentication	713/170
110	US 53534 03 A	<input checked="" type="checkbox"/>	Graphic display processing apparatus and method for improving the speed and efficiency of a window system	345/563
111	US 52874 52 A	<input checked="" type="checkbox"/>	Bus caching computer display system	345/520
112	US 52838 64 A	<input checked="" type="checkbox"/>	Computer apparatus and method for graphical flip book	345/776
113	US 52673 11 A	<input checked="" type="checkbox"/>	Intelligent diskette for software protection	705/56
114	US 52475 24 A	<input checked="" type="checkbox"/>	Method for generating a checksum	714/807
115	US 52280 54 A	<input checked="" type="checkbox"/>	Power-of-two length pseudo-noise sequence generator with fast offset adjustment	708/252
116	US 52186 47 A	<input checked="" type="checkbox"/>	Method to convert between 2 color space on a 32 bit .mu.-processor	382/166
117	US 52085 93 A	<input checked="" type="checkbox"/>	Method and structure for decoding Huffman codes using leading ones detection	341/65
118	US 51577 80 A	<input checked="" type="checkbox"/>	Master-slave checking system	714/31
119	US 51286 58 A	<input checked="" type="checkbox"/>	Pixel data formatting	345/600
120	US 51247 01 A	<input checked="" type="checkbox"/>	Quantization device with variable digital coding rate	341/61
121	US 50143 27 A	<input checked="" type="checkbox"/>	Parallel associative memory having improved selection and decision mechanisms for recognizing and sorting relevant patterns	382/220
122	US 49929 46 A	<input checked="" type="checkbox"/>	Data link for gas turbine engine control	701/100
123	US 48398 39 A	<input checked="" type="checkbox"/>	Barrel shifter including rotate operation	708/209
124	US 47853 93 A	<input checked="" type="checkbox"/>	32-Bit extended function arithmetic-logic unit on a single chip	712/221
125	US 47409 27 A	<input checked="" type="checkbox"/>	Bit addressable multidimensional array	365/238
126	US 46530 19 A	<input checked="" type="checkbox"/>	High speed barrel shifter	708/209
127	US 46266 74 A	<input checked="" type="checkbox"/>	Focus detecting method and apparatus	250/201 .8
128	US 46137 48 A	<input checked="" type="checkbox"/>	Focus detection apparatus employing image height correction	250/201 .8
129	US 45800 43 A	<input checked="" type="checkbox"/>	Apparatus for detecting focus condition of imaging lens having a circular detecting array	250/201 .8
130	US 43921 20 A	<input checked="" type="checkbox"/>	Pattern inspection system	382/199
131	US 43800 46 A	<input checked="" type="checkbox"/>	Massively parallel processor computer	712/22

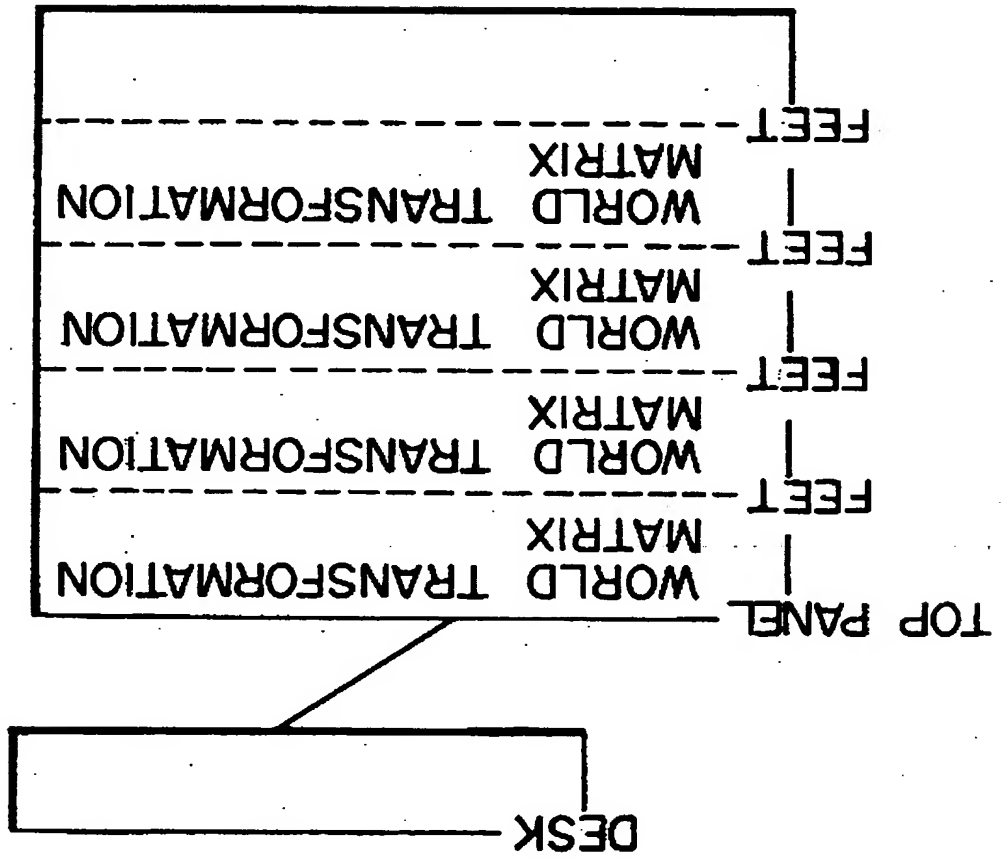
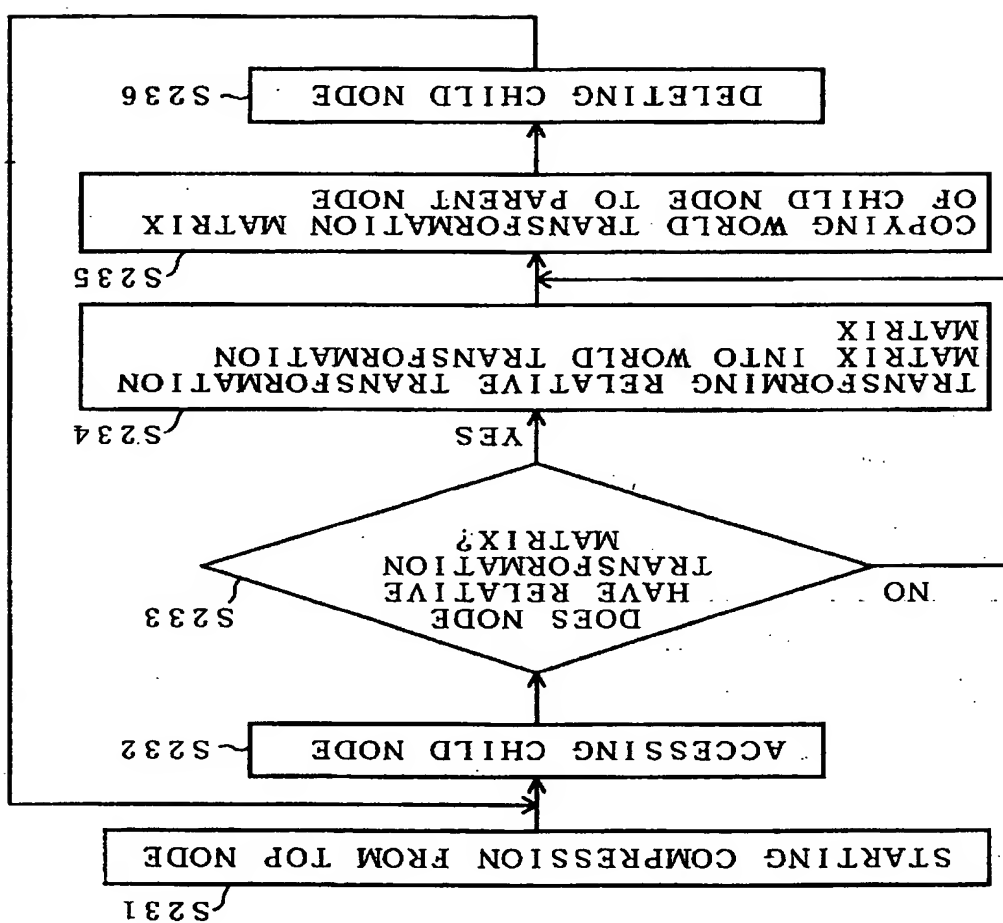


FIG. 90

	Docum ent ID	U	Title	Current OR
132	US 43655 66 A	<input checked="" type="checkbox"/>	Switch pattern selection and informational display arrangement for a multiple pattern sewing machine	112/444
133	US 43564 34 A	<input checked="" type="checkbox"/>	Multiple color single gun TV picture tube	315/375
134	US 42901 21 A	<input checked="" type="checkbox"/>	Variable function programmed calculator	365/189 .07
135	US 42426 75 A	<input checked="" type="checkbox"/>	Display and keyboard scanning for electronic calculation or the like	345/168
136	US 42375 32 A	<input checked="" type="checkbox"/>	Table driven decision and control logic for digital computers	712/236
137	US 42109 60 A	<input checked="" type="checkbox"/>	Digital computer with overlapped operation utilizing conditional control to minimize time losses	712/230
138	US 41998 11 A	<input checked="" type="checkbox"/>	Microprogrammable computer utilizing concurrently operating processors	712/23
139	US 41424 93 A	<input checked="" type="checkbox"/>	Closed loop exhaust gas recirculation control system	123/568 .21
140	US 41387 19 A	<input checked="" type="checkbox"/>	Automatic writing systems and methods of word processing therefor	358/1.1 8
141	US 40854 47 A	<input checked="" type="checkbox"/>	Right justified mask transfer apparatus	712/224
142	US 40743 51 A	<input checked="" type="checkbox"/>	Variable function programmed calculator	712/32
143	US 40457 72 A	<input checked="" type="checkbox"/>	Automatic focusing system	382/134
144	US 40126 34 A	<input checked="" type="checkbox"/>	Automatic focusing system including quantizing means	250/201 .3
145	US 39463 70 A	<input checked="" type="checkbox"/>	Method of making light-dot distribution for the holographic storage of binary information with the aid of electronically controlled switching masks	365/125
146	US 38739 74 A	<input checked="" type="checkbox"/>	Scanning system for location and classification of patterns	382/134
147	US 37455 33 A	<input checked="" type="checkbox"/>	DIGITAL DATA STORAGE REGISTER MODULES	710/305
148	US 37455 32 A	<input checked="" type="checkbox"/>	MODULAR DIGITAL PROCESSING EQUIPMENT	710/316
149	US 35991 60 A	<input checked="" type="checkbox"/>	TIME DIVISION MULTIPLEXING	370/535
150	US 35764 36 A	<input checked="" type="checkbox"/>	METHOD AND APPARATUS FOR ADDING OR SUBTRACTING IN AN ASSOCIATIVE MEMORY	708/670

FIG. 91



	Docum ent ID	U	Title	Current OR
1	US 20040 07375 5 A1	<input type="checkbox"/>	Broadcast invalidate scheme	711/144
2	US 20040 05487 8 A1	<input checked="" type="checkbox"/>	Method and apparatus for rearranging data between multiple registers	712/221
3	US 20040 03682 9 A1	<input checked="" type="checkbox"/>	Imaging unit, optical write unit, optical read unit and image forming apparatus	349/141
4	US 20040 01442 7 A1	<input checked="" type="checkbox"/>	Method and apparatus for transferring data between a source register and a destination register	455/73
5	US 20030 23690 4 A1	<input checked="" type="checkbox"/>	Priority progress multicast streaming for quality-adaptive transmission of data	709/231
6	US 20030 23346 4 A1	<input checked="" type="checkbox"/>	Priority progress streaming for quality-adaptive transmission of data	709/231
7	US 20030 22339 7 A1	<input checked="" type="checkbox"/>	Process for generating codes for CDMA communications, system and computer program product therefor	370/342
8	US 20030 21711 9 A1	<input checked="" type="checkbox"/>	Replication of remote copy data for internet protocol (IP) transmission	709/219
9	US 20030 21078 5 A1	<input checked="" type="checkbox"/>	System and method for sign mask encryption and decryption	380/210
10	US 20030 20052 4 A1	<input checked="" type="checkbox"/>	Priority coloring for VLSI designs	716/19
11	US 20030 19008 5 A1	<input checked="" type="checkbox"/>	Single-instruction multiple-data (SIMD)-based algorithms for processing video data	382/250
12	US 20030 18433 9 A1	<input checked="" type="checkbox"/>	Integrated circuit device	326/47
13	US 20030 15443 3 A1	<input checked="" type="checkbox"/>	Method and apparatus for broadcasting scan patterns in a scan-based integrated circuit	714/726
14	US 20030 13809 8 A1	<input checked="" type="checkbox"/>	Executing permutations	380/28
15	US 20030 13297 5 A1	<input checked="" type="checkbox"/>	Method and apparatus for preventing satellite induced banding by selective pixel compensation	347/5
16	US 20030 12900 1 A1	<input checked="" type="checkbox"/>	Method of manufacturing semiconductor memory device and semiconductor memory device	399/200
17	US 20030 11302 9 A1	<input checked="" type="checkbox"/>	Skim encoding method for compression of a two dimensional array of data	382/244

COMPUTER GRAPHICS DATA DISPLAY DEVICE AND METHOD BASED ON A HIGH- SPEED GENERATION OF A CHANGED IMAGE

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a computer graphics device for displaying graphic data (hereinafter referred to as computer graphics data or CG data) through a computer, and more specifically to a CG data display device for generating and displaying a dot image.

2. Description of the Related Art

Recently, CG devices for generating and processing images through computer systems have been widely used in many fields of applications in industry. Among these devices, a CG dynamic image display system should present a high-speed performance to keep up with the movement of an object and should display generated images with high reality.

For example, the improvement in the CG animation technologies has increased the applications of CG simulations for easily presenting various virtual experiences. Increasing especially are "walk-through" applications of CG in which a user can freely walk through a virtual world and feel as if he or she were actually experiencing a specific world.

However, with a device for realizing such CG simulations, a user often passes through a wall or feels unusual in moving around, and therefore it is impossible to feel freely moving around. Thus required is a new technology of realizing a moving in a virtual world with high reality as if it were a real world.

With the conventional CG walk-through technologies, a user walks through a three-dimensional world regardless of the position of objects around a user because the contact between a user's viewpoint and an object in a virtual world is ignored in calculation for a shift of sight.

As a result, the user passes through a wall which cannot be actually passed, or is dug in a sidewalk. Thus, the user often gets lost.

As described above, since the conventional method ignores the contact between a user's viewpoint and an object in a virtual world, the virtual movement is far from a realistic movement. Especially, it is very difficult for general people who try a CG walk-through simulation to successfully move around as they wish. Furthermore, the conventional method offers the following problems.

Apart from a contact between a viewpoint and an object, a user cannot represent using a simple system the difference in interference between two hard objects, between two soft objects, and between a hard and a soft object in a clash of two objects.

Additionally, the user cannot move around with his or her viewpoint maintaining at a constant level in a virtual world. For example, when the user goes upstairs, his or her viewpoint smoothly rises obliquely upward. However, in a virtual CG world, the user either cannot go upstairs or repeats for each step a parallel or vertical movement, resulting in an unsmooth movement (shift of sight).

Furthermore, a common user cannot easily edit the virtual world for lack of a unit for easily defining the reaction and movement of an object such that the object starts any action in response to a clash of objects or at an external instruction, and for lack of a unit for easily grasping the definition.

Recently, a CG accelerator in a workstation has made remarkable progress toward a higher speed and performance. Consequently realized is a CG system capable of displaying at a high speed a photo-realistic image. Thus, the time correspondence between a dynamic CG image and a real world can be successfully realized. However, the present technologies have just reached a logical time description, and have not developed a method for general purpose of representing CG images in three dimensions or four dimensions including time in a real-time mode. It is because the CG image display time depends on the complexity in form and cannot be standardized. To solve these problems and integrate the processes of multimedia, it is necessary to fix the time correspondence between a three-dimensional CG image and a real world.

Conventionally, a dynamic CG image has been generated and displayed in a sequential process on completion of the calculation for generation of an image for each frame. Therefore, the generation and display of a frame take a calculation/display time for the generation of an image. Thus, the frame interval between the display time t_{n-1} of the $(n-1)$ -th frame and the display time t_n of the n -th frame is considerably long.

In the conventional method, the change of dynamic CG images in time is described only logically, and no system is provided to keep correspondence between a displayed image and the logical description. Therefore, the logically described changes in time cannot be precisely regenerated and displayed. Practically, the time taken for a display process depends on each frame to be displayed because frames are different from one another in image complexity represented by the number of polygons, textures, etc. Furthermore, the time taken for calculation of changes of three-dimensional images also depends on the number of changing objects and the complexity in the calculation. Accordingly, the time taken for the calculation and display of a frame depends on each frame.

However, in the conventional method, frames to be displayed at given intervals in a logically described CG world have been sequentially displayed on completion of respective processes. Therefore, the time flows constantly for respective frames in the CG world, but the frames are displayed at different intervals, thereby failing in representing the actual time flow. Although the frames should be flow in the CG world, the frames are actually displayed at different intervals, the time being extended or reduced in the world displayed on the screen, because the time taken for calculation or display of the frames depends on the complexity of each image. If the frames should be set such that they can be displayed at constant intervals without a deviation from actual time, they must be set at intervals of the maximum value of the time taken for the calculation and display of the frames. Thus, frames are set at undesirably long intervals and generate a problem that resultant dynamic images cannot be smoothly displayed at all.

As described above, since images are sequentially generated through necessary calculation according to the conventional method, image frames are displayed at long intervals. Additionally, since there has been no system for keeping correspondence between the time in the world on the screen and the actual time, the time flow cannot be regenerated exactly.

Recently, computer animation is very popular in various fields of applications such as architectures, commercial

	Docum ent ID	U	Title	Current OR
18	US 20030 10143 0 A1	<input checked="" type="checkbox"/>	PRIORITY COLORING FOR VLSI DESIGNS	716/19
19	US 20030 09925 1 A1	<input checked="" type="checkbox"/>	Method and system for buffering a data packet for transmission to a network	370/429
20	US 20030 08441 9 A1	<input checked="" type="checkbox"/>	Row-based placement scoring and legalization measure for books with phase shift mask dependencies	716/19
21	US 20030 06133 2 A1	<input checked="" type="checkbox"/>	Multiple consumer-multiple producer rings	709/223
22	US 20030 05580 3 A1	<input checked="" type="checkbox"/>	Reversing the order of a group of objects in logarithmic time	706/48
23	US 20030 04642 3 A1	<input checked="" type="checkbox"/>	Programmable system for processing a partitioned network infrastructure	709/238
24	US 20030 00510 3 A1	<input checked="" type="checkbox"/>	Cumulative status of arithmetic operations	709/223
25	US 20030 00185 0 A1	<input checked="" type="checkbox"/>	Graphic processing system having bus connection control functions	345/503
26	US 20020 18882 1 A1	<input checked="" type="checkbox"/>	Fast priority determination circuit with rotating priority	711/220
27	US 20020 17596 1 A1	<input checked="" type="checkbox"/>	Printing apparatus and printing method	347/15
28	US 20020 14365 0 A1	<input checked="" type="checkbox"/>	Ordering method and system	705/26
29	US 20020 14058 5 A1	<input checked="" type="checkbox"/>	TECHNIQUE FOR ENCODING A SEQUENCE OF PERIODIC BYTE VALUES WITH VERTICAL CORRELATION	341/60
30	US 20020 13870 3 A1	<input checked="" type="checkbox"/>	System and method for building packets	711/154
31	US 20020 10656 7 A1	<input checked="" type="checkbox"/>	Phase-shifting mask and method of forming pattern using the same	430/5
32	US 20020 09863 9 A1	<input checked="" type="checkbox"/>	Method of manufacturing semiconductor memory device and semiconductor memory device	438/238
33	US 20020 06063 6 A1	<input checked="" type="checkbox"/>	Digital-to-analog conversion circuit and image display apparatus using the same	341/150
34	US 20020 05687 8 A1	<input checked="" type="checkbox"/>	Semiconductor memory device	257/365

films, educational programs, designing skills, etc. In the computer animation, the time taken for the generation of animation can be considerably reduced by calculating and processing the movement and transformation of an enormous number of objects using a computer system. Recently, in the computer animation, physical rules have been used to display animation images to represent visually natural movement of objects.

If a long time is taken for calculation to generate animation requiring a large amount of calculation processes for a large number of objects, then visually unrealistic animation images are generated. Accordingly, even if large amount of calculation is required for a large number of objects, it is necessary to quickly perform the calculation and display so that natural and smooth animation images can be realized.

Generally, an animation generating device using computer graphics fundamentally comprises an animation data generating unit for calculating the movement and transformation of objects and an image data generating unit for generating image data (two-dimensional data) from computed geometric data of objects (three-dimensional data of a form, position, etc.). Using these units, the animation generating device repeats computing the movement and transformation of objects and generating images to produce animation images. If the animation data generating unit and the image data generating unit perform calculating and generating processes at a high speed, smooth animation images can be generated in real time.

Conventionally, a large amount of processes have been performed at a high speed in the image data generating unit through high-performance hardware (accelerator) and firmware. On the other hand, since the animation data generating unit is required to generate animation images with more realistic movements and complicated transformations out of a large amount of data, its load is undeniably large and a long time is taken for the generation of data for a single frame.

However, the conventional animation generating device needs a long time for generating data calculating the movement and transformation of the whole objects, and then generates an image.

Therefore, if it takes the animation data generating unit a longer time to calculate the movement and transformation of objects than it takes the image data generating unit to display generated images, the images are displayed at longer intervals. As a result, smooth and unrealistic animation images appear on a screen. Thus, a high-speed image data generating unit has not generated animation images in real time.

A flight simulator and a drive simulator are required not only to display a static image predetermined by a computer but also to display animation images, and a device like a scene simulator is required to precisely draw a real scene. These devices display the form of an object to be displayed using a large amount of CG data. To represent a change of viewpoints and natural movements of objects appearing in an image, a large amount of CG data should be changed at very short intervals.

Conventionally, a CG data display device has performed the following process using a single central processing unit (CPU).

The CG data display device stores and updates CG data to be displayed in a data management process. Then, it reads all CG data containing those changed through an image generating process and generates images. It finally displays the images of CG data after sequentially repeating the update of the CG data and the generation of images.

The conventional CG data display device generates and displays images in an image generating process as described above. Such CG data image generation is a time-consuming process, and images are not generated in good time when a large amount of CG data must be updated. Therefore, resultant unrealistic images should be used with a part of CG data regularly omitted. A scene simulator is also required to display minute representation of objects. Therefore, for example, a long time is taken before displaying a minute object image when a viewpoint is changed.

That is, when a large amount of CG data of dynamic images are changed at very short intervals, an image generating process cannot be completed in good time, thereby generating unrealistic animation images. Moreover, in generating static images, an operator has to kill time while the images are being generated.

As computer graphics make striking progress and are used in various fields in industry, the development of more easily operated user interfaces are earnestly demanded. One of the demanded technologies is a three-dimensional object display method of generating a three-dimensional model, editing the model (modeling), and displaying the object in three dimensions. The "displaying the object in three dimensions" indicates a display of a three-dimensional world on a screen. In the development of a user interface, managing parts objects in a hierarchical structure and constructing data such that each data inherits the attribute of its parent effectively reduce the number of specified entries and are used in many modeling systems.

In this method, however, when a modeled three-dimensional form is displayed, including the attribute of a parent requires all hierarchical tree structure to be searched, thereby consuming much time in a displaying process.

The amount of search time affects the displaying process, and depends on the depth of a hierarchy of an object data structure (that is, the number of steps of the hierarchy) and the number of objects in the object data structure.

FIG. 1 shows the configuration of the important portion of a common three-dimensional object display device for processing computer graphics. The device generates and edits a three-dimensional image at a certain point. The device shown in FIG. 1 comprises an object generating and editing unit 1, an editing-formatted hierarchical object data structure memory unit 2, an object displaying process unit 3, and a display device 4.

A user (that is, a designer) instructs the object generating and editing unit 1 to model data, and simultaneously instructs the object displaying process unit 3 to display data. Therefore, the object generating and editing unit 1 and the object displaying process unit 3 execute their processes while accessing the same data structure. During this modeling process, the internal data structure is hierarchically arranged in object units, and the data are stored in the hierarchical object data structure storing unit 2.

FIG. 2 is an example of a hierarchical object data structure. The object data are hierarchically arranged in object units (that is, for each node) as shown in FIG. 2 in the modeling process.

For example, in modeling a "room", an object is generated as a parent and root representing a room. To this parent object, connected are child objects a "chair", a "desk", and a "wall". The "room" has its attributes "color A" and "transformation matrix M1". The "desk" has its attributes "color C", "transformation matrix M3", and "form a". The

	Docum ent ID	U	Title	Current OR
35	US 20010 03756 1 A1	<input checked="" type="checkbox"/>	Contacting-making system for two printed circuit boards	29/745
36	US 20010 03362 6 A1	<input checked="" type="checkbox"/>	System, method and computer program for decoding an encoded data stream	375/341
37	US 20010 02874 7 A1	<input checked="" type="checkbox"/>	Image processing method, apparatus and storage medium	382/239
38	US 20010 02865 9 A1	<input checked="" type="checkbox"/>	Data switching arbitration arrangements	370/413
39	US 67193 97 B1	<input checked="" type="checkbox"/>	Ink jet printhead identification circuit and method	347/19
40	US 67013 38 B2	<input checked="" type="checkbox"/>	Cumulative status of arithmetic operations	708/525
41	US 66980 08 B2	<input checked="" type="checkbox"/>	Row-based placement scoring and legalization measure for books with phase shift mask dependencies	716/19
42	US 66665 35 B2	<input checked="" type="checkbox"/>	Method and apparatus for preventing satellite induced banding by selective pixel compensation	347/5
43	US 66265 17 B2	<input checked="" type="checkbox"/>	Printing apparatus and printing method	347/40
44	US 66256 89 B2	<input checked="" type="checkbox"/>	Multiple consumer-multiple producer rings	711/110
45	US 66092 45 B2	<input checked="" type="checkbox"/>	Priority coloring for VLSI designs	716/21
46	US 65634 40 B1	<input checked="" type="checkbox"/>	Apparatus and method for decoding Huffman codes using leading one/zero string length detection	341/65
47	US 65453 23 B2	<input checked="" type="checkbox"/>	Semiconductor memory device including a pair of MOS transistors forming a detection circuit	257/365
48	US 65011 16 B2	<input checked="" type="checkbox"/>	Semiconductor memory device with MIS transistors	257/296
49	US 64990 39 B1	<input checked="" type="checkbox"/>	Reorganization of striped data during file system expansion in a data storage system	707/204
50	US 64593 92 B1	<input checked="" type="checkbox"/>	Technique for encoding a sequence of periodic byte values with vertical correlation	341/87
51	US 64217 30 B1	<input checked="" type="checkbox"/>	Programmable system for processing a partitioned network infrastructure	709/236
52	US 64046 64 B1	<input checked="" type="checkbox"/>	Twisted bit line structure and method for making same	365/69
53	US 64011 17 B1	<input checked="" type="checkbox"/>	Platform permitting execution of multiple network infrastructure applications	709/223
54	US 63662 76 B1	<input checked="" type="checkbox"/>	Touch operation signal output device	345/175
55	US 63424 08 B1	<input checked="" type="checkbox"/>	Method of manufacturing semiconductor memory device	438/155

Third, a smooth and realistic animation is realized by an increased number of display times at shorter image display intervals and at a high speed display.

Second, data are displayed at short frame intervals with display time and actual time corresponding to each other calculation processes.

First, simplified is an editing process in which a virtual CG world is defined so that a simulation of realistic and lifelike movements and changes of states can be easily realized at a high speed through a smaller amount of

SUMMARY OF THE INVENTION

As shown in FIG. 1, since both the object generating/editing process 1 and the object displaying process 3 access the object data in the hierarchical object data structure memory unit 2 in performing a modeling process and a displaying process, the hierarchical object data structure which is effectively used in a modeling operation is used as is in a display process. Therefore, with the increasing number of objects, an enormous number of object searching processes are carried out, thereby taking much process time to display data.

However, to make such a hierarchical modeling data taking the attributes of the parent object into consideration each object in a hierarchical object data structure while object display processing unit 3 searches for and displays which data are displayed on the display device 4, the object display processing unit 3 searches for and displays number of displaying operations should be performed to allow a user to issue a display instruction without considering the number of objects and the depth of hierarchy. Furthermore, an enormous number of displaying operations should be performed to allow a user to issue a display instruction without considering the number of objects and the depth of hierarchy. Furthermore, an enormous number of displaying operations should be performed to allow a user to issue a display instruction without considering the number of objects and the depth of hierarchy.

If a "foot" is composed of two parts, then it is a parent object to the two parts having attitudes of respective forms. In this case, a modeling operation can be performed without specifying their foot color or transformation matrix because the child objects inherit the attributes of their parent objects. If the color of the entire legs or the texture of the chair should be changed, only the color attribute B or the texture attribute of the chair has to be changed to simultaneously change the entire legs including four respective feet because each foot inherits the attributes of its parent objects. Inheriting attributes enables a user interface to be provided and modeled without redundant entries specified by a user.

If a "foot" is composed of two parts, then it is a parent object to the two parts having attitudes of respective forms. In this case, a modeling operation can be performed without specifying their foot color or transformation matrix because the child objects inherit the attributes of their parent objects. If the color of the entire legs or the texture of the chair should be changed, only the color attribute B or the texture attribute of the chair has to be changed to simultaneously change the entire legs including four respective feet because each foot inherits the attributes of its parent objects. Inheriting attributes enables a user interface to be provided and modeled without redundant entries specified by a user.

Through the time control as described above, each frame of dynamic images can be displayed at a time corresponding to the actual time for the frame without affecting the realistic representation in the virtual world.

If a reestimated display time is earlier than the predicted time, then the generating unit extends the display of the frame and displays it at the predicted time. If the reestimated display time is much later than the predicted time, then the frame is not displayed.

Further, the calculation process can be considerably reduced for a calculation process. Furthermore, the calculation is simplified and the time taken for a calculation process can be considerably reduced.

Since the management unit and the generating unit are independent of each other, the management unit performs a calculation process on a frame, and the generating unit performs a displaying process on another frame concurrently in a pipeline system, thereby speeding up the entire process.

Introducing an interference attribute and a reaction attribute diversifies the movement of an object in a virtual world and realizes a realistic shift of a viewpoint.

Furthermore, the calculation is simplified and the time taken for a calculation process can be considerably reduced.

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	Docum ent ID	U	Title	Current OR
56	US 63266 95 B1	<input checked="" type="checkbox"/>	Twisted bit line structures and method for making same	257/776
57	US 63046 26 B1	<input checked="" type="checkbox"/>	Two-dimensional array type of X-ray detector and computerized tomography apparatus	378/19
58	US 62920 18 B1	<input checked="" type="checkbox"/>	Configurable cellular array	326/41
59	US 62808 88 B1	<input checked="" type="checkbox"/>	Phase-shifting mask with multiple phase-shift regions	430/5
60	US 62633 53 B1	<input checked="" type="checkbox"/>	Method and apparatus for converting between different digital data representation formats	708/204
61	US 62558 48 B1	<input checked="" type="checkbox"/>	Method and structure for reading, modifying and writing selected configuration memory cells of an FPGA	326/41
62	US 62526 08 B1	<input checked="" type="checkbox"/>	Method and system for improving shadowing in a graphics rendering system	345/473
63	US 61822 53 B1	<input checked="" type="checkbox"/>	Method and system for automatic synchronous memory identification	714/718
64	US 61768 62 B1	<input checked="" type="checkbox"/>	Hair-removing device with rotary roller equipped with pain-soothing device	606/133
65	US 61692 41 B1	<input checked="" type="checkbox"/>	Sound source with free compression and expansion of voice independently of pitch	84/605
66	US 61579 55 A	<input checked="" type="checkbox"/>	Packet processing system including a policy engine having a classification unit	709/228
67	US 61548 09 A	<input checked="" type="checkbox"/>	Mathematical morphology processing method	711/108
68	US 61304 61 A	<input checked="" type="checkbox"/>	Semiconductor memory device	257/369
69	US 61140 95 A	<input checked="" type="checkbox"/>	Method of manufacturing electronic device using phase-shifting mask with multiple phase-shift regions	430/311
70	US 61081 01 A	<input checked="" type="checkbox"/>	Technique for printing with different printer heads	358/1.9
71	US 61012 76 A	<input checked="" type="checkbox"/>	Method and apparatus for performing two pass quality video compression through pipelining and buffer management	382/236
72	US 60661 80 A	<input checked="" type="checkbox"/>	Automatic generation of phase shift masks using net coloring	716/19
73	US 60141 87 A	<input checked="" type="checkbox"/>	Display device	349/15
74	US 59950 80 A	<input checked="" type="checkbox"/>	Method and apparatus for interleaving and de-interleaving YUV pixel data	345/603
75	US 59912 49 A	<input checked="" type="checkbox"/>	Optical track sensing device	369/44. 42
76	US 59832 91 A	<input checked="" type="checkbox"/>	System for storing each of streams of data bits corresponding from a separator thereby allowing an input port accommodating plurality of data frame sub-functions concurrently	710/52
77	US 59661 38 A	<input checked="" type="checkbox"/>	Image processing method and apparatus for rotating an image in an area of an original	345/658
78	US 59419 37 A	<input checked="" type="checkbox"/>	Layout structure for barrel shifter with decode circuit	708/209

The management unit does not simultaneously calculate the movements of all objects in a screen, but calculates them separately and transmits the results to the generating unit. Each time the generating unit receives a calculation result, it converts the result into image data for display. Thus, the image data are displayed at short intervals, thereby displaying smooth dynamic images.

If the minimal CG data indicating the type of change are transmitted from the management unit to the generating unit as change data, then the transmission cost can be considerably reduced.

The generating unit stores tree-structured object data in a compressed format in which data are stored in a smaller number of layers and as smaller number of objects than those stored in the management unit, thereby shortening the search time for display. Thus, an attribute-inheritable object can be effectively edited and a displaying process can be performed at a high speed.

According to the CG data display device and method of the present invention, image data are updated and displayed at a high speed to generate precise and realistic dynamic images.

BRIEF DESCRIPTION OF THE DRAWINGS

- FIG. 1 shows the configuration of the important portion of a common three-dimensional object display device;
 FIG. 2 shows an example of a hierarchical object data structure;
 FIG. 3 shows the configuration of the computer graphics data display device according to the embodiment of the present invention;
 FIG. 4 is the block diagram showing the configuration of the first embodiment;
 FIG. 5 shows an example of a virtual world illustrating the first embodiment of the present invention;
 FIG. 6 shows an example of the object information about a steps forming part of the virtual world;
 FIG. 7 shows an example of the object information about a handrail forming part of the virtual world;
 FIG. 8 shows an example of the object information about a window forming part of the virtual world;
 FIG. 9 shows an example of the object information about a floor forming part of the virtual world;
 FIG. 10 shows an example of the object information about a door forming part of the virtual world;
 FIG. 11 shows an example of the object information about a door knob forming part of the virtual world;
 FIG. 12 shows an example of the object information about a box forming part of the virtual world;
 FIG. 13 shows an example of the object information about a viewpoint forming part of the virtual world;
 FIG. 14 shows the structure of the attribute setting menu according to the first embodiment of the present invention;
 FIG. 15 shows an example of a display of the interference attribute according to the first embodiment of the present invention;
 FIG. 16 shows an example of a display of the attribute of the steps according to the first embodiment of the present invention;
 FIG. 17 shows an example of a display of the reaction attribute according to the first embodiment of the present invention;
 FIG. 18A shows an example of a setting screen of the reaction attribute of the contact switch according to the first embodiment of the present invention;

- FIG. 18B shows an example of a setting screen of the reaction attribute of the rotating object according to the first embodiment of the present invention;
 FIG. 18C shows an example of a setting screen of the reaction attribute of the sound generating object according to the first embodiment of the present invention;
 FIG. 19 is the process flowchart according to the first embodiment of the present invention;
 FIG. 20 is the flowchart showing the movement interference calculation process between an object and a wall;
 FIG. 21 is the flowchart showing the movement interference calculation process between the object and the steps;
 FIG. 22 shows an example of the amendment to the position of the object interfering with the steps;
 FIG. 23 is the flowchart showing the movement interference calculation process between the object and the floor;
 FIG. 24 shows an example of the amendment to the position of the object interfering with the floor;
 FIG. 25 is the flowchart showing the movement interference calculation process between the object and a sliding door;
 FIG. 26 shows the configuration according to the second embodiment of the present invention;
 FIG. 27 shows the time relationship between the calculation process and the display process according to the second embodiment;
 FIG. 28 shows an example of a process performed when a prediction error generates the inversion of time in the second embodiment;
 FIGS. 29 and 30 are the process flowchart of the time control unit;
 FIGS. 31 is the process flowchart of the predicting unit;
 FIG. 32 is the process flowchart of the calculating unit;
 FIG. 33 is the process flowchart of the display unit;
 FIG. 34 shows the changing object management unit;
 FIG. 35 shows an example of the configuration of the system according to the second embodiment;
 FIG. 36 shows the configuration of the important portion according to the third embodiment of the present invention;
 FIG. 37 is the process flowchart of the device according to the third embodiment;
 FIG. 38 shows the data structure of the animation data storage unit shown in FIG. 36;
 FIG. 39 shows the contents of each object;
 FIG. 40 shows the animation data;
 FIG. 41 is the correspondence list of the animation method and the data;
 FIG. 42 shows an example of the internal configuration of the animation data generating unit shown in FIG. 36;
 FIG. 43 shows the internal configuration of the update control unit shown in FIG. 36;
 FIG. 44 is the flowchart of the process performed by the animation data generating unit;
 FIG. 45 is the flowchart of the process performed by the update control unit;
 FIG. 46 shows an example of the internal configuration of the animation data generating unit for weighting the animation method;
 FIG. 47 is the flowchart of the process performed by the data acquiring unit;
 FIG. 48 shows an example of the internal configuration of the animation data generating unit for weighting the number of polygon;

	Docum ent ID	U	Title	Current OR
79	US 59278 71 A	<input checked="" type="checkbox"/>	Printer having scroll print buffer and printing method	400/61
80	US 58959 56 A	<input checked="" type="checkbox"/>	Semiconductor memory device	257/350
81	US 58838 13 A	<input checked="" type="checkbox"/>	Automatic generation of phase shift masks using net coloring	716/19
82	US 58752 00 A	<input checked="" type="checkbox"/>	Reed-Solomon code system employing k-bit serial techniques for encoding and burst error trapping	714/784
83	US 58700 97 A	<input checked="" type="checkbox"/>	Method and system for improving shadowing in a graphics rendering system	345/426
84	US 58676 90 A	<input checked="" type="checkbox"/>	Apparatus for converting data between different endian formats and system and method employing same	710/65
85	US 58643 75 A	<input checked="" type="checkbox"/>	Display device	349/15
86	US 58617 61 A	<input checked="" type="checkbox"/>	Hierarchically connectable configurable cellular array	326/41
87	US 58547 60 A	<input checked="" type="checkbox"/>	Two-dimensional PE array, content addressable memory, data transfer method and mathematical morphology processing method	365/49
88	US 58448 25 A	<input checked="" type="checkbox"/>	Bidirectional shifter circuit	708/209
89	US 58354 96 A	<input checked="" type="checkbox"/>	Method and apparatus for data alignment	370/514
90	US 58314 48 A	<input checked="" type="checkbox"/>	Function unit for fine-gained FPGA	326/41
91	US 58124 72 A	<input checked="" type="checkbox"/>	Nested loop method of identifying synchronous memories	365/201
92	US 57986 56 A	<input checked="" type="checkbox"/>	Match register with duplicate decoders	326/39
93	US 57861 12 A	<input checked="" type="checkbox"/>	Photomask manufacturing process and semiconductor integrated circuit device manufacturing process using the photomask	430/5
94	US 57777 22 A	<input checked="" type="checkbox"/>	Scanning exposure apparatus and method	355/53
95	US 57649 38 A	<input checked="" type="checkbox"/>	Resynchronization of a superscalar processor	712/200
96	US 57548 05 A	<input checked="" type="checkbox"/>	Instruction in a data processing system utilizing extension bits and method therefor	712/200
97	US 57318 53 A	<input checked="" type="checkbox"/>	Display device	349/15
98	US 57200 21 A	<input checked="" type="checkbox"/>	Image processing apparatus for storing image data to a page memory	345/581
99	US 57174 40 A	<input checked="" type="checkbox"/>	Graphic processing having apparatus for outputting FIFO vacant information	345/558
100	US 56803 40 A	<input checked="" type="checkbox"/>	Low order first bit serial finite field multiplier	708/492
101	US 56708 97 A	<input checked="" type="checkbox"/>	High speed mask register for a configurable cellular array	326/41

FIG. 49 shows an example of the internal configuration of the animation data generating unit comprising a moving object list generating unit.

FIG. 50 is the flowchart of the process performed by the moving object list generating unit.

FIG. 51 shows an example of the moving object list structure.

FIG. 52 shows an example of the configuration of another configuration of the important portion of the third embodiment.

FIG. 53 is the block diagram according to the fourth embodiment of the present invention.

FIG. 54 shows the configuration of the system according to the fourth embodiment.

FIG. 55 shows the configuration of the CG data management unit.

FIG. 56 shows the configuration of the CG data image generating unit.

FIG. 57 is the flowchart of the operation of the first processing unit.

FIG. 58 is the detailed flowchart of the CG data management process.

FIG. 59 is the detailed flowchart of the CG calculation process.

FIG. 60 is the flowchart of the operation of the second processing unit.

FIG. 61 is the detailed flowchart of the CG data image generating process.

FIG. 62 shows the time relationship between the process performed by the first processing unit and that performed by the second processing unit.

FIG. 63 shows the configuration of the flight simulator according to the fourth embodiment.

FIG. 64 shows the configuration of the test course simulator according to the fourth embodiment.

FIG. 65 shows the configuration of the scene simulator according to the fourth embodiment.

FIG. 66A shows an example of the display screen of the drive simulator according to the fourth embodiment.

FIG. 66B shows an example of the changed display screen of the drive simulator according to the fourth embodiment.

FIG. 67 shows the data structure according to the structure of the C language.

FIG. 68 is the flowchart of the data retrieval process.

FIG. 69 shows the shift of the viewpoint.

FIG. 70 shows an example of the configuration of the CG data.

FIG. 71 shows the configuration of another system according to the fourth embodiment.

FIG. 72 shows the fourth embodiment realized by the multiprocess capabilities.

FIG. 73 shows the configuration of the important portion according to the fifth embodiment.

FIG. 74A shows an example of a hierarchical object data structure composed of three objects.

FIG. 74B shows an example of a hierarchical object data structure compressed by ignoring the inheritance of objects.

FIG. 75 shows an example of a hierarchical object data structure compressed according to color attributes according to the fifth embodiment.

FIG. 76A shows an example of the hierarchical object data structure inheriting a transformation matrix.

FIG. 76B shows an example of a hierarchical object data structure compressed according to transformation matrix attributes according to the fifth embodiment.

FIG. 77A shows an example of the hierarchical object data structure inheriting a relative transformation matrix.

FIGS. 77B shows an example of a hierarchical object data structure compressed according to relative transformation matrix attributes according to the fifth embodiment.

FIG. 78 shows the contents of each node of the tree structure.

FIG. 79 is the flowchart of the process performed by the object data structure compressing unit shown in FIG. 73.

FIG. 80 shows an example of a pointer to a child node.

FIG. 81 shows a desk in the world coordinate system.

FIG. 82 shows the modeling coordinate system of the top panel.

FIG. 83 shows the modeling coordinate system of the foot.

FIG. 84 shows the world transformation matrix of the top panel and the world transformation matrix of the foot.

FIG. 85 shows the transformation matrix in the three-dimensional graphics.

FIG. 86 shows the relative transformation matrix of the foot.

FIG. 87 shows the hierarchical object data structure having a relative transformation matrix as an attribute.

FIG. 88 shows an example of the hierarchical object data structure having an attribute of a world transformation matrix.

FIG. 89 shows another example of the hierarchical object data structure having an attribute of a world transformation matrix.

FIG. 90 shows the compressed hierarchical object data structure having a world transformation matrix as an attribute.

FIG. 91 is the flowchart of the compressing process of the hierarchical object data structure having matrix information as an attribute.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention are explained below by referring to the attached drawings.

FIG. 3 shows a configuration of the CG data display device according to the embodiment of the present invention. The CG data display device shown in FIG. 3 comprises a management unit 11 for receiving CG data and performing calculation according to the information input externally and a generating unit 21 for generating image data from the CG data output by the management unit 11 and transmitting them to a display unit not shown in FIG. 3.

The display unit displays on a screen the image data received from the generating unit 21.

The management unit 11 comprises an object information memory unit 12, a state change calculating unit 13, a predicting unit 14, a time control unit 15, an animation data generating unit 16, an update control unit 17, a first processing unit 18, and an editing-format hierarchical object data structure memory unit 19.

The generating unit 21 comprises an image data generating unit 22, a second processing unit 23, and a display-format hierarchical object data structure memory unit 24.

The object information memory unit 12 stores attributes indicating interference and reaction between objects to be displayed. The state change calculating unit 13 calculates a state change of objects according to the attributes of the objects stored in the object information memory unit 12.

	Docum ent ID	U	Title	Current OR
102	US 56689 41 A	<input checked="" type="checkbox"/>	Optimum implementation of X-Y clipping on pixel boundary	345/626
103	US 56627 85 A	<input checked="" type="checkbox"/>	Method for masking a workpiece and a vacuum treatment facility	204/298 .25
104	US 56595 57 A	<input checked="" type="checkbox"/>	Reed-Solomon code system employing k-bit serial techniques for encoding and burst error trapping	714/752
105	US 56492 25 A	<input checked="" type="checkbox"/>	Resynchronization of a superscalar processor	712/23
106	US 56110 64 A	<input checked="" type="checkbox"/>	Virtual memory system	711/209
107	US 56029 86 A	<input checked="" type="checkbox"/>	Data processing and memory systems with retained background color information	345/502
108	US 55862 56 A	<input checked="" type="checkbox"/>	Computer system using multidimensional addressing between multiple processors having independently addressable internal memory for efficient reordering and redistribution of data arrays between the processors	710/100
109	US 55527 22 A	<input checked="" type="checkbox"/>	Mask register for a configurable cellular array	326/41
110	US 55465 32 A	<input checked="" type="checkbox"/>	Data-array processing system	345/556
111	US 55398 98 A	<input checked="" type="checkbox"/>	Data-array processing system wherein parallel processors access to the memory system is optimized	711/167
112	US 55281 76 A	<input checked="" type="checkbox"/>	Register with duplicate decoders for configurable cellular array	326/105
113	US 55262 96 A	<input checked="" type="checkbox"/>	Bit field operating system and method with two barrel shifters for high speed operations	708/209
114	US 55198 29 A	<input checked="" type="checkbox"/>	Data-array processing and memory systems	345/530
115	US 55006 09 A	<input checked="" type="checkbox"/>	Wildcard addressing structure for configurable cellular array	326/41
116	US 54973 95 A	<input checked="" type="checkbox"/>	Method and apparatus for modulating signal waveforms in a CDMA communication system	370/209
117	US 54716 28 A	<input checked="" type="checkbox"/>	Multi-function permutation switch for rotating and manipulating an order of bits of an input data byte in either cyclic or non-cyclic mode	712/223
118	US 54695 47 A	<input checked="" type="checkbox"/>	Asynchronous bus interface for generating individual handshake signal for each data transfer based on associated propagation delay within a transaction	713/600
119	US 54690 03 A	<input checked="" type="checkbox"/>	Hierarchically connectable configurable cellular array	326/39
120	US 54503 13 A	<input checked="" type="checkbox"/>	Generating local addresses and communication sets for data-parallel programs	717/151
121	US 54480 75 A	<input checked="" type="checkbox"/>	Electron-beam exposure system having an improved rate of exposure throughput	250/492 .22
122	US 54404 26 A	<input checked="" type="checkbox"/>	Optical spatial filtering for attenuating the zero diffractive orders of mutually incoherent light beams	359/559
123	US 54147 01 A	<input checked="" type="checkbox"/>	Method and data structure for performing address compression in an asynchronous transfer mode (ATM) system	370/395 .3

The predicting unit 14 predicts time taken for data calculation in management unit 11 and time taken for generation of image data in the generating unit 21. The time control unit 15 performs time control on the data calculation and the image data generation according to the prediction by the predicting unit 14.

The animation data generating unit 16 calculates a form and a position of an object to update CG data. The update control unit 17 controls the number of objects generated at one time by the animation data generating unit 16.

The first processing unit 18 manages CG data. When the CG data are subject to a change, the CG data associated with the change are output as change data. The second processing unit 23 stores the CG data, and upon receipt of the change data, it updates the CG data based on the change data, and generates image data.

The editing-format hierarchical object data structure memory unit 19 stores a hierarchical object data structure in an editorial form. The display-format hierarchical object data structure memory unit 24 stores the hierarchical object data structure in a display form.

The object information memory unit 12 and the state change calculating unit 13 are explained in association with the first embodiment of the present invention. The predicting attribute defining/setting unit 33 defines an interference attribute indicating the restrictions as the constraint condition on the movement of the second object. For example, if an attribute of a "wall" is defined, then another object (including a user's viewpoint) that may interfere the wall can be included in a movement interference calculation such that the interfering object cannot pass through an object assigned the wall attribute.

Upon receipt of an input from the input device 31, the viewpoint volume defining unit 34 defines a size and a form of a volume of a viewpoint around the user's viewpoint. The viewpoint volume is regarded as space surrounding the position of user's eyes, and processed in a movement interference calculation. The state change calculating unit 13 allows the user's viewpoint to move around at a constant height in a virtual world by calculating the movement of the viewpoint based on the correlation between the viewpoint volume and the attribute of another object.

The attribute defining/setting unit 33 defines and sets an attribute indicating an average slope angle which is a constraint condition set when a viewpoint or a specific object passes over an object having an interference restriction attribute of, for example, steps. If the attribute is defined, the state change calculating unit 13 calculates based on the average slope angle the movement of the viewpoint or the specific object moving over the object assigned the attribute.

The attribute defining/setting unit 33 also defines and sets an attribute, using a restriction at the time of an interference as a contact force parameter function, indicating restriction information depending on the contact force generated by an interference. The state change calculating unit 13 calculates not only the existence of an interference but also the contact force generated by the interference so that an attribute of, for example, a paper partition, which indicates no influence if a small contact force is given but is broken by a large contact force, can be realized.

Furthermore, the attribute defining/setting unit 33 defines and sets as a reaction attribute a reaction movement of an object having an interference as an activation switch. The reaction attribute determines the moment or the method of a state change of an object in a movement interference calculation on the object performed by the state change calculating unit 13.

The object information memory unit 12 stores form data of an object, position information and other physical information for each object in the virtual world. According to the first embodiment, the object information memory unit 12 comprises an attribute memory unit 36 for storing an interference attribute or a reaction attribute of an object.

The state change calculating unit 13 calculates a state change of an object according to the attribute of an associated object stored in an attribute memory unit 36 as a reaction or in response to an external activate instruction. An attribute distribution display unit 37 displays the attribute information of each object stored in the attribute memory unit 36. A result display unit 38 displays a result of the calculation performed by the state change calculating unit 13. A sound output unit 39 outputs a sound or a voice when a sound output is defined as a reaction attribute of an object.

A display device 40 is a graphic display device for displaying the virtual world. A sound output device 41 is an output device comprising a speech synthesizing device or a speaker.

The predicting unit 14 predicts time taken for data calculation in management unit 11 and time taken for generation of image data in the generating unit 21. The time control unit 15 performs time control on the data calculation and the image data generation according to the prediction by the predicting unit 14.

The animation data generating unit 16 calculates a form and a position of an object to update CG data. The update control unit 17 controls the number of objects generated at one time by the animation data generating unit 16.

The first processing unit 18 manages CG data. When the CG data are subject to a change, the CG data associated with the change are output as change data. The second processing unit 23 stores the CG data, and upon receipt of the change data, it updates the CG data based on the change data, and generates image data.

The editing-format hierarchical object data structure memory unit 19 stores a hierarchical object data structure in an editorial form. The display-format hierarchical object data structure memory unit 24 stores the hierarchical object data structure in a display form.

The object information memory unit 12 and the state change calculating unit 13 are explained in association with the first embodiment of the present invention. The predicting attribute defining/setting unit 33 defines an interference attribute indicating the restrictions as the constraint condition on the movement of the second object. For example, if an attribute of a "wall" is defined, then another object (including a user's viewpoint) that may interfere the wall can be included in a movement interference calculation such that the interfering object cannot pass through an object assigned the wall attribute.

Upon receipt of an input from the input device 31, the viewpoint volume defining unit 34 defines a size and a form of a volume of a viewpoint around the user's viewpoint. The viewpoint volume is regarded as space surrounding the position of user's eyes, and processed in a movement interference calculation. The state change calculating unit 13 allows the user's viewpoint to move around at a constant height in a virtual world by calculating the movement of the viewpoint based on the correlation between the viewpoint volume and the attribute of another object.

The attribute defining/setting unit 33 defines and sets an attribute indicating an average slope angle which is a constraint condition set when a viewpoint or a specific object passes over an object having an interference restriction attribute of, for example, steps. If the attribute is defined, the state change calculating unit 13 calculates based on the average slope angle the movement of the viewpoint or the specific object moving over the object assigned the attribute.

The attribute defining/setting unit 33 also defines and sets an attribute, using a restriction at the time of an interference as a contact force parameter function, indicating restriction information depending on the contact force generated by an interference. The state change calculating unit 13 calculates not only the existence of an interference but also the contact force generated by the interference so that an attribute of, for example, a paper partition, which indicates no influence if a small contact force is given but is broken by a large contact force, can be realized.

Furthermore, the attribute defining/setting unit 33 defines and sets as a reaction attribute a reaction movement of an object having an interference as an activation switch. The reaction attribute determines the moment or the method of a state change of an object in a movement interference calculation on the object performed by the state change calculating unit 13.

	Docum ent ID	U	Title	Current OR
124	US 54086 32 A	<input checked="" type="checkbox"/>	Semiconductor memory having a bit position decoder and date re-ordering circuitry for arranging bits in a word of data	365/230 .06
125	US 53409 92 A	<input checked="" type="checkbox"/>	Apparatus and method of detecting positional relationship using a weighted coefficient	250/548
126	US 52804 88 A	<input checked="" type="checkbox"/>	Reed-Solomon code system employing k-bit serial techniques for encoding and burst error trapping	714/784
127	US 52768 00 A	<input checked="" type="checkbox"/>	Image writing control unit having memory area for image	345/561
128	US 52766 91 A	<input checked="" type="checkbox"/>	Method for the control of receiver synchronization in a mobile phone	714/798
129	US 52476 88 A	<input checked="" type="checkbox"/>	Character recognition sorting apparatus having comparators for simultaneous comparison of data and corresponding key against respective multistage shift arrays	707/7
130	US 52185 62 A	<input checked="" type="checkbox"/>	Hamming data correlator having selectable word-length	708/422
131	US 52184 31 A	<input checked="" type="checkbox"/>	Raster image lossless compression and decompression with dynamic color lookup and two dimensional area encoding	348/472
132	US 51121 49 A	<input checked="" type="checkbox"/>	Velocity responsive head driving control apparatus of manual sweeping printer	400/88
133	US 51037 49 A	<input checked="" type="checkbox"/>	Process and sewing machine for sewing together layers of fabric according to a pattern	112/475 .03
134	US 50955 23 A	<input checked="" type="checkbox"/>	Signal processor including programmable logic unit formed of individually controllable output bit producing sections	712/42
135	US 50954 46 A	<input checked="" type="checkbox"/>	Circuit for and method of controlling output buffer memory	345/571
136	US 50918 74 A	<input checked="" type="checkbox"/>	Encoder apparatus	708/211
137	US 50738 64 A	<input checked="" type="checkbox"/>	Parallel string processor and method for a minicomputer	708/212
138	US 50460 23 A	<input checked="" type="checkbox"/>	Graphic processing system having bus connection control capable of high-speed parallel drawing processing in a frame buffer and a system memory	345/619
139	US 49998 08 A	<input checked="" type="checkbox"/>	Dual byte order data processor	712/300
140	US 48961 33 A	<input checked="" type="checkbox"/>	Parallel string processor and method for a minicomputer	340/146 .2
141	US 48432 36 A	<input checked="" type="checkbox"/>	Movable object position detecting method and apparatus	250/231 .1
142	US 48021 16 A	<input checked="" type="checkbox"/>	Programmed controller	703/23
143	US 46087 06 A	<input checked="" type="checkbox"/>	High-speed programmable timing generator	377/39
144	US 44425 27 A	<input checked="" type="checkbox"/>	Synchronization systems	375/134
145	US 43897 06 A	<input checked="" type="checkbox"/>	Digital computer monitored and/or operated system or process which is structured for operation with an improved automatic programming process and system	700/1
146	US 43261 90 A	<input checked="" type="checkbox"/>	Boundary trace slope feature detection system	382/197

The attribute defining unit 33 also defines and sets a reaction attribute indicating a state change of an object at an instruction from the input device 31 so as to enable a reaction attribute defined and set for the object to be activated on an occasion other than an interference. At an activate instruction from the activate instruction input unit 35, the state change calculating unit 13 checks the reaction attribute of the object, and changes the state of the object in accordance with the reaction attribute.

Furthermore, the attribute defining unit 33 defines and sets as one of reaction attributes a sound output attribute indicating an output of a specified sound or voice. When an object having a sound output attribute comes in contact with another object, or when an activate instruction is issued to the object having the sound output attribute, the sound output unit 39 outputs a specified sound or voice through the sound output device 41.

The attribute distribution display unit 37 refers to the attribute memory unit 36 and displays the information about the attribute defined and set for an object in the virtual world with the object in the virtual world.

The present invention can speed up a movement interference calculation of an object and realize the feeling of a realistic movement in a virtual world by introducing the concept of an interference attribute and a reaction attribute to an object in a virtual world. That is, post-interference states of objects can be easily calculated and realized by referring to, for example, a predetermined interference attribute. Therefore, a viewpoint or a moving object can be prevented from being buried in a wall or other objects. Furthermore, the movement of a user's viewpoint can be realistically realized in a walk-through simulation, and a common user not familiar with CG can smoothly move in the virtual world.

According to the present invention, a restriction can be defined and set on an object as an interference attribute when objects interfere with each other in a virtual world. For example, if an object is assigned an attribute of a "wall" and it is also defined that a user's viewpoint, that is, an interfering object, cannot pass through the object assigned the attribute of a wall, then the user's viewpoint determines a contact with the wall at a walk-through simulation. The viewpoint does not pass into the wall when it comes in contact with the wall, but it moves along the wall, thereby solving the problem that the viewpoint passes through the wall and gets lost.

Especially, the viewpoint volume defining unit 34 defines the size, form, etc. for a user's viewpoint volume and performs an interference calculation using size, form, etc. of the viewpoint so that the user can walk around at a constant height or a user's height on an object having an attribute of a "floor" as an interference attribute. Although, a user walks through a fence according to the conventional technologies, the present invention enables the fence to be set such that a user cannot pass through it by defining the user's viewpoint volume. Thus, a more realistic viewpoint movement can be realized.

For example, an attribute of "steps" can be defined as an interference restriction attribute, and an average slope angle can be defined and set so that a user goes smoothly up and down on them at a specified slope angle. Although a user could not go up or down the steps or has unrealistically walked up and down the steps, the present invention easily realizes a realistic walking up and down the steps.

Furthermore, a restriction at the time of an interference can be defined and set as a parameter function of a contact

force, and the contact force (physical quantity of, for example, a collision force product) between objects associated with the interference is calculated so that an attribute of a "paper partition", which is not affected at a small contact force but is broken at a large contact force, can be defined. As a result of an interference, not only a constraint condition on the movement of an interfering object associated with an interference but also the reaction movement with the interference as a trigger of an activate switch is defined and set as one of attributes. Thus, defined is an "object movable upon interference" as a type of attribute. For example, realized are an attribute of an "automatic door" to be moved by a switch of another object's interference and an attribute of a "variation" which starts a varying animation operation such as a free form deformation (FFD). Therefore, a realistic simulation world can be easily realized with a larger number of variations.

A reaction attribute assigned to an object can also be defined for a moment other than the time of an interference. For example, defined is an object reacting as being triggered by a switch at an external activate instruction, for example, a user's mouse click on a screen. Thus, an attribute of an "automatic door" to be started only by an interference can be easily extended to a door opened by a user's click depending on the definition of a switch. Therefore, a very realistic and fantastic walk-through simulation can be easily realized.

Furthermore, a sound as well as a movement can be set as a reaction attribute. The attribute defining unit 33 defines a sound output attribute as a reaction attribute, and calculates unit 13 displays an image movable according to an activated reaction attribute, and activates the sound output unit 39 if a sound output attribute is specified, outputs the sound, and displays dynamic images.

Thus, an attribute of a "sound" is realized as a reaction with a switch, and can be defined as a kind of attribute in an increasing number of multimedia systems in recent simulation fields.

The attribute distribution display unit 37 displays a reaction attribute defined and set for an object and a switch activated by the attribute so as to practically indicate what is set in a world. For example, a virtual world in which a number of objects exist. Thus solved is the problem that a common user sets a switch for a wrong object or forgets as to which object an activation switch is assigned.

FIG. 5 shows an example of a virtual world for use in explaining the first embodiment. FIGS. 6 through 13 show examples of the information of objects forming the virtual world shown in FIG. 5.

In the first embodiment, the following typical attributes are used. The names and contents of the attributes are examples only and referred to for easier explanation. It is obvious that the present invention is not limited to these attributes but can simultaneously assign various attributes. A wall, steps, a paper partition, and a floor are provided as interference attributes in the present example shown in FIG. 5.

The attribute of a wall refers to the feature of an object that the viewpoint cannot walk on the object having this attribute which permits nothing to pass through the object even if the object is sloping. When an object is defined in a virtual world, the default interference attribute is a "wall". The attribute of "steps" has a parameter of an average slope angle calculated using real form of steps and the information about the lowest plane in the gravity direction.

	Docum ent ID	U	Title	Current OR
147	US 43259 10 A	<input checked="" type="checkbox"/>	Automated multiple-purpose chemical-analysis apparatus	422/64
148	US 43002 98 A	<input checked="" type="checkbox"/>	Apparatus for the production and display of moving pictures	40/430
149	US 42272 45 A	<input checked="" type="checkbox"/>	Digital computer monitored system or process which is configured with the aid of an improved automatic programming system	700/95
150	US 42198 74 A	<input checked="" type="checkbox"/>	Data processing device for variable length multibyte data fields	712/300
151	US 42165 28 A	<input checked="" type="checkbox"/>	Digital computer implementation of a logic director or sequencer	700/95
152	US 42154 07 A	<input checked="" type="checkbox"/>	Combined file and directory system for a process control digital computer system	700/95
153	US 42154 06 A	<input checked="" type="checkbox"/>	Digital computer monitored and/or operated system or process which is structured for operation with an improved automatic programming process and system	700/95
154	US 42031 54 A	<input checked="" type="checkbox"/>	Electronic image processing system	345/26
155	US 41308 80 A	<input checked="" type="checkbox"/>	Data storage system for addressing data stored in adjacent word locations	711/201
156	US 40842 59 A	<input checked="" type="checkbox"/>	Apparatus for dot matrix recording	358/3.2
157	US 40657 56 A	<input checked="" type="checkbox"/>	Associative memory with neighboring recirculated paths offset by one bit	365/49
158	US 39926 97 A	<input checked="" type="checkbox"/>	Character recognition system utilizing feature extraction	382/203
159	US 38824 63 A	<input checked="" type="checkbox"/>	Character recognition apparatus	382/217
160	US 38724 33 A	<input checked="" type="checkbox"/>	OPTICAL CHARACTER RECOGNITION SYSTEM	382/175
161	US 37665 32 A	<input checked="" type="checkbox"/>	DATA PROCESSING SYSTEM HAVING TWO LEVELS OF PROGRAM CONTROL	712/247
162	US 37522 88 A	<input checked="" type="checkbox"/>	ELECTROGRAPHIC PRINTER WITH PLURAL OSCILLATING PRINT HEAD	400/322
163	US 36171 34 A	<input checked="" type="checkbox"/>	OPTICAL IMAGE FRAME COORDINATE DATA DETERMINING SYSTEM	356/141 .3
164	US 35681 55 A	<input checked="" type="checkbox"/>	METHOD OF STORING AND RETRIEVING RECORDS	707/2

The information about the lowest plane indicates the information about a horizontal plane in contact with the floor among a lot of planes forming a staircase. For example, the information refers to a plane number of the lowest plane. The viewpoint can go up and down along the slope angle. The attribute of a paper partition refers to the feature of an object that the viewpoint can walk on the object having this attribute however steep or even vertical the object is. Various of walks (for example, a walking at a constant height from the floor) can be realized by appropriately setting the viewpoint (height of the viewpoint or eyes).

The reaction attributes in the first embodiment indicate a reaction movement and sound, or indicate an activation switch. The reaction attributes indicating a movement refer to rotation, parallel movement, and sound.

The attribute of "rotation" refers to the feature of an object that the object automatically starts rotating as being triggered by a switch. Using this attribute, specified are a start/end position, the type of rotation such as a fixed direction, a reverse direction, etc. For example, needles of a clock, a door knob, a rotating door, an opening/closing of a book, a drawbridge, etc. can be realized using the attribute.

The attribute of "parallel movement" refers to the feature of an object that the object starts automatic parallel movement by being triggered by a switch. With this attribute, specified are a plane on which a movement is made, a start/end position of the movement, the type of movement such as one-way, two-way, etc. For example, the attribute can be used to realize a sliding door, a window, a drawer, etc.

The attribute of a "sound" (sound output attribute) refers to the feature of an object that the object outputs a sound or a voice by being triggered by a switch according to sound data preliminarily stored in the object.

For example, a virtual world comprises the objects shown in FIG. 5. First, the objects are defined. Since the form, position, etc. of an object can be defined as in the prior art technologies, the detailed explanation about them is omitted here. Described below in detail is the data structure after the definition of the objects. According to the first embodiment, an attribute can be assigned to each object on an attribute edit screen.

The object information about steps 51 shown in FIG. 5 is managed as the data as shown in FIG. 6. The information refers to data of a common type and therefore common objects. The bounding volume refers to a size of a space including the object and is determined for easier cross over calculation. The position matrix refers to the position of the object in a three-dimensional space of the virtual world. The name refers to the identifier of the object. In this case, the name is "steps A". The interference attribute data are attribute information set by the attribute defining/setting unit 33 shown in FIG. 4. The attribute type is "steps". The data include a parameter of the average slope angle of 30° and the information about the lowest plane in the gravity direction (plane number of the lowest plane). The viewpoint can go up and down the steps at the slope angle. The texture data refer to the color, pattern (texture), etc. of the object. The color of

The object information about window 53 shown in FIG. 5 is managed as the data shown in FIG. 8. The attribute type of the interference attribute of the window 53 is a "paper partition" with the maximum pressure of 25.0. It indicates the durable pressure, and the window 53 permits an object to pass through it only when it receives a clash force equal to or larger than the pressure of 25.0. No reaction attribute data are defined for the window 53.

The object information about a floor 54 shown in FIG. 5 is managed as, for example, the data shown in FIG. 9. The attribute type of the interference attribute of the floor 54 is "floor". Therefore, the viewpoint can walk on this object. No reaction attribute data are defined. The object information of the wall 55 shown in FIG. 5 is defined similarly. The interference attribute of the wall 55 is defined at "wall".

The object information about a door 56 shown in FIG. 5 is managed as, for example, the data shown in FIG. 10. The attribute type of the interference attribute of the door 56 is "wall". Furthermore, the door 56 is assigned a reaction attribute, and the type of the attribute is "reaction". Its animation type is "rotation" and a rotation start/end position matrix is defined. It has a door knob as a switch and starts its rotation by the click on a door knob 57.

The object information about the door knob 57 shown in FIG. 5 is managed as, for example, the data shown in FIG. 11. The attribute type of the interference attribute of the door knob 57 is "wall". "Switch" is defined as the attribute type of the interference attribute of the door knob 57. The switch type is "click". The "click" indicates a clicking operation of, for example, a mouse on a screen, and permits a reacting object to be operated. In this example, the reacting object is the door 56.

The object information about a box 58 shown in FIG. 5 is managed as, for example, the data shown in FIG. 12. The attribute type of the interference attribute of the box 58 is "wall" which prohibits the viewpoint from walking over. Two attributes of "reaction" are defined as reaction attributes. One is the animation type "rotation" and associated with the viewpoint as a switch. When the object comes in contact with the viewpoint as described later, it starts a predetermined rotation. The other attribute is the animation type "sound" and indicates a reaction of outputting a sound. A use sound data used when the sound is output are preliminarily stored in an area managed by the identification information "sound 31". It is switched by the viewpoint. When the object comes in contact with the viewpoint as described later, it outputs the predetermined sound data.

The object information about a viewpoint 59 shown in FIG. 5 is managed as, for example, the data shown in FIG. 13. The data type of the viewpoint is "viewpoint". The viewpoint 59 indicates the position and direction of the eyes of a user who is supposed to walk in a virtual world. There are no physical data of the form, but the viewpoint is

	Docum ent ID	U	Title	Current OR
1	JP 20001 94719 A	<input type="checkbox"/>	METHOD AND DEVICE FOR MANAGING DATA	
2	JP 20001 33611 A	<input checked="" type="checkbox"/>	IMPLANTATION MASK	
3	JP 11024 039 A	<input checked="" type="checkbox"/>	IMAGE EXPOSING DEVICE	
4	JP 10189 745 A	<input checked="" type="checkbox"/>	SEMICONDUCTOR INTEGRATED CIRCUIT LAYOUT DEVICE	
5	JP 09114 639 A	<input checked="" type="checkbox"/>	MASK DATA GENERATION CIRCUIT AND BIT FIELD OPERATION CIRCUIT	
6	JP 09050 112 A	<input checked="" type="checkbox"/>	PHASE SHIFT MASK	
7	JP 08317 287 A	<input checked="" type="checkbox"/>	X-RAY IMAGE PICKUP DEVICE	
8	JP 08129 168 A	<input checked="" type="checkbox"/>	PROJECTION TYPE IMAGE DISPLAY DEVICE	
9	JP 07040 598 A	<input checked="" type="checkbox"/>	PRINT OUTPUT METHOD AND ITS CONTROL DEVICE FOR SERIAL PRINTER	
10	JP 06347 335 A	<input checked="" type="checkbox"/>	PHASE DIFFERENCE MEASURING APPARATUS	
11	JP 06276 483 A	<input checked="" type="checkbox"/>	PICTURE SIGNAL CODING METHOD, CODER, DECODING METHOD AND DECODER	
12	JP 06083 858 A	<input checked="" type="checkbox"/>	VECTOR INSTRUCTION PROCESSOR	
13	JP 05312 733 A	<input checked="" type="checkbox"/>	X-RAY INSPECTION	
14	JP 05139 790 A	<input checked="" type="checkbox"/>	MASK FILM FOR ION EXCHANGE TREATMENT	
15	JP 05021 321 A	<input checked="" type="checkbox"/>	ALIGNMENT DEVICE OF EXPOSURE DEVICE	
16	JP 04288 684 A	<input checked="" type="checkbox"/>	COLOR SPACE CONVERSION METHOD	
17	JP 04074 218 A	<input checked="" type="checkbox"/>	ARITHMETIC CIRCUIT	
18	JP 03173 474 A	<input checked="" type="checkbox"/>	SEMICONDUCTOR DEVICE	
19	JP 03044 734 A	<input checked="" type="checkbox"/>	DATA SHAPING CIRCUIT	
20	JP 02230 320 A	<input checked="" type="checkbox"/>	DATA PROCESSOR	
21	JP 02054 677 A	<input checked="" type="checkbox"/>	DECODING METHOD FOR VARIABLE LENGTH CODE	
22	JP 02046 084 A	<input checked="" type="checkbox"/>	IMAGE PICK-UP DEVICE	

The attribute defining/unit 33 shown in FIG. 4 defines and sets an attribute when a virtual world is edited or simulated. FIG. 14 shows the structure of the attribute setting menu processed by the attribute defining/unit 33. The "display" of an attribute or the "setting" of an attribute can be selected from the initial menu. In an "attribute display" menu, either "interference attribute display" or "reaction attribute display" can be selected.

FIG. 15 shows an example of a display of an interference attribute after being selected from the "interference attribute display" menu. If the "interference attribute display" is selected, an interference attribute of each object in the object information shown in FIGS. 6 through 13 is referred to. As shown in FIG. 15, for example, the name of an object and an interference attribute name already set are displayed in the virtual world. Thus, a user is informed of the set interference attribute.

Clicking a mouse at the displayed attribute on a screen opens a small window as shown in FIG. 16 for more detailed parameters. FIG. 16 shows a window displayed when the mouse is clicked at the attribute of the steps.

FIG. 17 shows an example of the display of reaction attributes displayed when the "reaction attribute display" menu is selected. When the "reaction attribute display" menu is selected, the reaction attributes of each object in the object information shown in FIGS. 6 through 13 are referred to. For example, as shown in FIG. 17, the reaction attributes set for each object are represented in respective colors. Otherwise, the distribution of the reaction attributes can be represented by letters "switch", "rotating object", etc., as in the example of the display of interference attributes. In this example, an object having the attribute of a switch is represented in pink, an object having the reaction attribute in pale blue, and the other objects in white depending on the type of reaction attribute. Thus, all objects assigned a reaction attribute are represented in respective colors. Then, clicking an optional switch, for example, the "door knob" displays the reaction attribute group ("door" in this example) switched by the "door knob" in an emphasized manner. That is, for example, pink is emphasized into red, pale blue is emphasized into blue, and so forth.

If the "interference attribute" setting menu is selected in the attribute setting menu as shown in FIG. 14, then displayed is the menu listing the interference attributes which can be set for an object to be set. For example, if a step which is referred to in association with the example of the display of interference attributes is displayed. In the example of the window shown in FIG. 16

which is referred to in association with the example of the display of interference attributes is displayed. In the window, an average slope angle is automatically calculated

FIGS. 18A, 18B, and 18C show examples of setting the "reaction attribute (switch)" setting menu is selected in the attribute setting menu shown in FIG. 14, a "click switch" and "contact switch" is displayed. On this screen, "click switch" indicates that a switch type reacts with an external activate instruction, while the "contact switch" indicates that a switch type reacts when the object comes in contact with another object in the virtual world. If the "contact switch" is selected, for example, a window shown in FIG. 18A is displayed. Adding, deleting, entering, and exiting a reacting object in the list is performed by clicking the button after selecting a corresponding item in the list. There are two methods of operating a window for use in setting the movement of an actual reacting object as shown in FIGS. 18B and 18C. One is to click the button at a corresponding object in the reacting objects to be activated. The other is to directly select on a screen a reacting object to be edited and to select a reaction attribute in the menu. FIG. 18B shows an example of the display of a window when the "rotating object" menu is selected in setting a reaction attribute. The rotation angle, the type of rotation, can be set in the window. Likewise, the movement/rotation position and the type of movement can be set for displaying object" using a similar screen.

FIG. 18C shows an example of the display of a window for the storing an acoustic performance time, a sound source, and sound data called "mididata" can be optionally set. Described below is the process performed by the state management calculating unit 13 shown in FIG. 4 by referring to FIG. 19. Process steps S1 through S19 in the following explanation correspond to steps S1 through S19 shown in FIG. 19.

S1: A display instruction is issued to the result display unit 38 to display the initial screen or the image of a calculation result on the display device 40.

S2: If there are sound data to be output, then the sound data is output through the sound output unit 39.

S3: Present time t is set to t' by adding a predetermined time value Δt ($t' = t + \Delta t$).

S4: On the screen displaying a virtual world, it is determined whether or not the button has been clicked at an object, that is, whether or not an activate instruction has been issued from the activate instruction input unit 35.

S5: If no, control is passed to step S7.

S6: If the button has been clicked at an object, the reaction attribute of the clicked object is checked to determine whether or not its switch attribute is defined. If no, the process in the next step S6 is omitted.

S7: If the switch attribute is defined, then searched and activated is a reacting object triggered by the clicked object.

S8: Next, it is determined whether or not there is an object moving in the virtual world. If no, control is returned to step S1. An object moving in FIG. 5 is an object which has been already activated among the viewpoint 59, the door 56, and the box 58.

S9: If there are objects moving in the virtual world, one (hereinafter referred to as observed and temps

	Docum ent ID	U	Title	Current OR
23	JP 02046 078 A	<input checked="" type="checkbox"/>	IMAGE PICK-UP DEVICE	
24	JP 01259 397 A	<input checked="" type="checkbox"/>	COLOR LIQUID CRYSTAL DISPLAY	
25	JP 01223 565 A	<input checked="" type="checkbox"/>	INFORMATION PROCESSOR	
26	JP 01223 564 A	<input checked="" type="checkbox"/>	INFORMATION PROCESSOR	
27	JP 01223 563 A	<input checked="" type="checkbox"/>	INFORMATION PROCESSOR	
28	JP 01012 215 A	<input checked="" type="checkbox"/>	SOLAR SENSOR	
29	JP 63151 948 A	<input checked="" type="checkbox"/>	EXPOSING MASK	
30	JP 62061 324 A	<input checked="" type="checkbox"/>	STAGE NOISE DETECTION OF ELECTRON BEAM EXPOSURE DEVICE	
31	JP 60070 836 A	<input checked="" type="checkbox"/>	TRANSMITTER	
32	JP 59146 008 A	<input checked="" type="checkbox"/>	FOCUSING DETECTOR	
33	NB891 0197	<input checked="" type="checkbox"/>	RMU Mask Generation From Shift Amount or Pad/Start/End Specifications	
34	NN870 6172	<input checked="" type="checkbox"/>	Increasing Memory Reliability Through Address Translation and Per Page Bit Swapping	
35	NN790 55027	<input checked="" type="checkbox"/>	Bit Matrix Transposition Algorithm., May 1979.	
36	NN780 23598	<input checked="" type="checkbox"/>	Mask Controlled Byte Handling. February 1978.	
37	US 20040 00574 4 A	<input checked="" type="checkbox"/>	Amorphous substrate crystallization apparatus for transistor fabrication, has convergence/divergence element and phase shift mask to produce light beam having periodical intensity distribution with inverse peak portion	
38	US 66188 04 B	<input checked="" type="checkbox"/>	Centrifuge circuit in digital computer, has swap stages which forward received mask bits and data units in reverse order, if mask bit received from specific mask bit positions are set and clear respectively	
39	US 20030 09897 0 A	<input checked="" type="checkbox"/>	Lens aberration monitor for optical lithography system, has phase shifting element arranged on mask to form ring-shaped pattern on substrate, for detecting lens aberration	
40	US 20020 16980 8 A	<input checked="" type="checkbox"/>	Bit reordering method in computer for cryptography involves centrifuging data element as function of masks that are created with reference to destination descriptor representing a reordering pattern of data element	
41	US 64082 75 B	<input checked="" type="checkbox"/>	Compressing and decompressing audio data by masking lower order bits of digital audio samples and shifting in higher order bits from adjacent sample	
42	FR 28053 61 A	<input checked="" type="checkbox"/>	Method of acquisition of rounding parameters in floating-point multiply accumulate, uses shifting of mantissa bits for easy fusion of incoming value with accumulated value	
43	JP 20003 52810 A	<input checked="" type="checkbox"/>	Phase shift mask for manufacture of semiconductor device, has shading element mounted in corner area at upper portion of shading band area arranged to enclose corner areas of circuit pattern	
44	CA 22758 21 A	<input checked="" type="checkbox"/>	Compression method for audio data in voice communication systems, by masking predetermined number of lower order bits from each sample of stream of digital audio samples	

reaction and/or reaction, or object B is a reading object with object A as a switch. If object B is a reading object

	Docum ent ID	U	Title	Current OR
45	US 61449 86 A	<input checked="" type="checkbox"/>	Data set sorting network for use in parallel processor environment, includes control mask which is shuffled whenever redundant shuffling operation is performed on data elements	
46	JP 09114 639 A	<input checked="" type="checkbox"/>	Bit field operation circuit with mask data generating circuit - has shifter which responds to 2-bit shifter control signal and shifts 16-bits of 32-bit mask bits and outputs as mask data	
47	EP 57371 2 B	<input checked="" type="checkbox"/>	Prod'n. of wavelength converter element - comprises forming stripe mask on lithium, tantalate C-plate, exchanging lithium ions with protons in non-masked portions	
48	DE 41410 24 A	<input checked="" type="checkbox"/>	Conversion of colour image signals - using 32-bit microprocessor employing shift and masking operations	
49	RD 30505 2 A	<input checked="" type="checkbox"/>	Parity generation logic for rotate-merge unit - uses rotator output predictor to generate parity whilst rotate-merge unit is operating	
50	DE 36863 07 G	<input checked="" type="checkbox"/>	Binary image rotation method for digital image processor - exchanged selected group of bits stored in register with second group of bits stored in second register	
51	SU 11676 13 A	<input checked="" type="checkbox"/>	Microprogram computer multiplex channel - has microprogram memory at inputs of exchange status former, mask register and data switching unit taken to data registers	
52	SU 11176 32 A	<input checked="" type="checkbox"/>	Data shift circuit for array element ordering - has four ordering code formers each with NOT-gate and four multiplexers, and eight adders at inputs of switches	
53	EP 90137 A	<input checked="" type="checkbox"/>	Access control system for data transfer of variable length records - between central processing units and direct access stores, updating buffer address register as writing progresses	
54	SU 86434 0 B	<input checked="" type="checkbox"/>	High output computer data shift unit - has mask generator outputs connected to high and low order bits of output register	
55	US 40657 56 A	<input type="checkbox"/>	Associative charge coupled memory - has neighbouring recirculated memory paths offset by one bit and has large number of word locations	

and is switched by object A, then the process of the next step S19 is performed. Otherwise, control is returned to step S7.

S19: Object B is activated and added to a group of the moving objects as one of them. Then, control is returned to step S7 and the process is repeated on the next moving object.

Next, the process in step S15 shown in FIG. 19 is explained in detail by referring to FIGS. 20 through 25, where object A is a viewpoint assigned a viewpoint volume.

FIG. 20 is the flowchart showing the movement interference calculation in which the attribute of object B is "wall". In FIG. 20, the state change calculating unit 13 determines whether or not the interference pressure of object A is larger than the maximum pressure of object B (step S21). If yes, the temporary update of the movement of object A is validated and the position of object A is updated (step S23).

If it is smaller than the maximum pressure of object B, then the temporary update of the movement of object A is not updated (step S22). In this case, the position of object A is canceled (step S22). In this case, the position of object A is not updated.

FIG. 21 is the flowchart of the movement interference calculation performed when the attribute of object B is "steps". FIG. 22 shows the position of object A amended as a result of the calculation.

In FIG. 21, the state change calculating unit 13 obtains the intersection between the center line in the gravity direction of the bounding volume of temporarily updated object A and the lowest plane of object B, that is, the intersection P1 between the vertical line from the center of object A to the lowest plane of object B and the lowest plane of object B (step S31). Obtained next is the amended point P2 on an average slope line according to the intersection P1 and an average slope angle of object B (step S32). Then, the position of object A is amended such that the lowest point of the bounding volume of object A matches the amended point P2, and then object A is moved (step S33).

Thus, as shown in FIG. 22, the bounding volume of the temporarily updated object A is moved onto the average slope line of object B.

FIG. 23 is a flowchart of the movement interference calculation performed when the attribute of object B is "floor". FIG. 24 shows a position of object A amended as a result of the calculation.

In FIG. 23, the state change calculating unit 13 obtains the distance L1 between the center of the bounding volume of the temporarily updated object A and object B (step S41). Obtained next is the depth L2 of the bounding volume of object A sinking into object B by subtracting L1 from the radius of the bounding volume of object A. L2 is added to the height of the center of the bounding volume of object A to obtain an amended point of the center (step S42). Then, the position of object A is amended such that the bounding volume of object A comes in contact with object B, and object A is moved (step S43).

Thus, as shown in FIG. 24, the bounding volume of the temporarily updated object A is moved onto object B. FIG. 25 is the flowchart of the process performed in the movement interference calculation if the attribute of object B is "paper partition". In FIG. 25, the state change calculating unit 13 determines whether or not the interference pressure of object A is larger than the maximum pressure of object B (step S51).

If yes, the temporary update of the movement of object A is validated and the position of object A is updated (step S52). Next, it is determined whether or not there is a reaction movement as a result of which object B is broken (step S53).

If yes, then the reaction movement of object B is activated (step S54). If no, the process terminates.

If the interference pressure of object A is smaller than the maximum pressure, then the temporary update of the movement of object A is canceled (step S55), and the processes of and after step S53 are performed. At this time, the position of object A is not updated.

To obtain an exact movement interference, an interference calculation should be performed between all intersecting planes of object A with object B, and the contact force at each intersection is calculated to obtain the direction of the movement of object A and the distance of the movement. In this method, a large amount of calculation is required to determine for each plane the intersection and the contact force. Furthermore, to realize the state after a contact, a precise physics calculation should be performed using a contact force and a friction force.

On the other hand, according to the first embodiment, it is not necessary to determine an intersection for all planes of object A. Furthermore, the amount of movement is used to determine the state after a contact, and reaction information is stored for each attribute, thereby eliminating a precise and complex physics calculation. As a result, the large amount of calculation in the precise movement interference calculation can be considerably reduced.

The above explanation of the processes refers to the typical attributes. If a new attribute is defined, then a process routine can be entered depending on its attribute. Similarly, the calculation can be easily performed depending on the attribute. The movement interference calculation for the new attribute can be optionally set. Various methods, for example, a method of generating a subroutine, a method using a branch table, etc. can be used depending on the system of a CG simulation.

As described above, the first embodiment introduces a concept of an attribute, and defines and sets the attribute for an object in a virtual world in a walk-through simulation. Then, the movement interference calculation of the object is performed at a high speed and the conventional problem that the object undesirably sinks into another object can be successfully solved. Thus, the movement of the viewpoint of a user can be performed easily and realistically.

FIG. 26 shows the configuration of the second embodiment of the present invention.

The second embodiment is a CG data display system for generating and displaying image frames which change one after the other as time passes. The system comprises a calculating unit 61 for calculating CG data to be displayed, a display unit 62 for displaying a calculation result per-

n-frame performed by the calculating unit 61 and the display of the (n-1)-th frame on the display unit 62 such that these processes are concurrently performed. It changes the interval of the display of frames according to the prediction output by the predicting unit 14.

The time control unit 15 predicts the frame display time using the predicting unit 14 before actual calculation to set time of a world to be displayed through computer graphics corresponding to the logically described actual time. Setting the time of the displayed world corresponding to the actual time means that an image generated through CG data

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